1956

Optimum farm plans for beginning farmers in central Iowa--an application of linear programming

Arthur Buren Mackie
Iowa State College

NOTE TO USERS

OPTIMUM FARM PLANS FOR BEGINNING FARMERS IN CENTRAL IOWA--AN APPLICATION OF LINEAR PROGRAMMING

by

Arthur Buren Mackie

A Dissertation Submitted to the
Graduate Faculty in Partial Fulfillment of
The Requirements for the Degree of
DOCTOR OF PHILOSOPHY

Major Subject: Agricultural Economics

Approved:

Signature was redacted for privacy.

In Charge of Major Work

Signature was redacted for privacy.

Head of Major Department

Signature was redacted for privacy.

Dean of Graduate College

Iowa State College
1956

TABLE OF CONTENTS

INTRODUCTION

Getting established in farming has become more difficult for young farmers in recent years, partly because of the increased amount of capital required to carry on a farm business. Too, the need for improvements in managerial ability has grown with the increased need for capital. The problems of farm planning thus become more acute in the case of beginning farmers, because they usually have access to relatively small amounts of capital and have limited farming experience. Many young farmers, aware of the gains which may be obtained from improved farm planning, have turned to the Extension Service for some assistance. Consequently, in order to provide the assistance requested, the Iowa Agricultural Extension Service has under way a program in farm and home planning for beginning farmers. This program is designed to provide the necessary technical information and guidance in farm organization.

The success of an educational program for young farmers, however, depends upon the basis on which recommendations are made. Information, based on empirical evidence, is needed to determine the way in which capital limitations affect income opportunities under different farming situations. Such information is helpful in deciding the most profitable way of investing limited funds. The amount of profits and, therefore, the length of time required to get established may

depend on the choice of enterprises and the manner in which limited resources are allocated among enterprises. Hence, research is needed to determine and outline the alternative income opportunities, from different combinations of enterprises, open to young farmers. From these results, certain guide posts for use in decision making could be established. These guide posts, which consider individual goals, managerial ability and resource supplies, should be useful as bases for directing recommendations to young farmers seeking to get established and, at the same time, maximize incomes. It is to the problem of selecting an optimum combination of crop and livestock enterprises on crop-share rented farms that this study is addressed.

OBJECTIVES OF STUDY

The specific objective of this study is to determine plans which best fit the resources of beginning farmers on crop-share rented farms in central Iowa. There is not a "one best plan" for all farmers on the same soil type and farm size. Rather, the "best plan" for a particular farm should vary with the amount of available capital, land, labor, building facilities, and managerial ability. Hence, as a guide for counseling beginning farmers in farm and home planning, optimum plans have been worked out for various resource and management situations. This analysis attempts to determine the most profitable combination of enterprises for tenants with different quantities of capital and different levels of management on 160 acre farms when rotations are not specified. (A few plans are computed, however, when rotations are fixed by the landlord.) This procedure is followed since quite different recommendations may be appropriate for tenants with different managerial ability and different resource supplies.

AREA OF STUDY AND ENTERPRISES CONSIDERED

Location and Farm Situation

Hardin County was selected for this study because it was one of the first counties to initiate an educational program specifically designed to aid beginning operators in farm and home planning. The farm chosen for this study by the Hardin County Extension Staff was judged to be typical of those managed by the young farmers with which they were working. Its predominant soil type is Clarion-Webster. The farm selected is considered to be typical in terms of soil type, leasing conditions, farm size, and type and quantity of building and machinery facilities. The farm is 160 acres in size, with 153 acres in field crops and pasture and the remaining 7 acres used for farmstead, roads and fences. The leasing system is crop-share.[1] The service buildings on the farm consist of: poultry housing, grain storage facilities, a dairy barn, and a hog house. The poultry housing is adequate for a laying flock of 100 hens. Grain and hay storage facilities are adequate to handle the production from the

---

[1]The tenant pays as rent one-half of the corn and soybeans, two-fifths of the oats and a cash payment of ten dollars an acre for all hay and pasture land. The cost of fertilization is shared equally by the tenant and landlord.

cropland. The dairy barn consists of 1176 square feet of building space suitable for milking and care of replacements. The floor arrangement is such that with a minimum amount of work it can be adapted to swine production. In addition to this possible area for hogs there are 504 square feet of hog house available. Therefore, the total building space available for hogs is 1680 square feet[1] while only 1176 square feet is available for the dairy enterprise.

The tenant supplies all machinery and labor to carry on the farm operations. The labor supply consists of the operator alone supplying 275 man hours per month from March through October and 260 man hours from November through February. In addition, 90 hours of family labor is available from April through August, 25 hours available in September and October, 15 hours available per month from November through February, and 75 hours available in March. The housewife's labor is assumed sufficient for a poultry enterprise; therefore it does not compete with other enterprises for non-housewife labor. The man hours of housewife labor available amounts to one hour per day during the months of January, February, November, and December; one and one-half hours per day during

---

[1]In the main portion of this study the hog enterprise competes for both the dairy and hog building space. However, a few plans are computed with the hog enterprise limited to the hog building space (504 square feet).

March, April, September, and October; two hours per day for May, June, July, and August.

The cropping history of all farms in Lee Township, Franklin County and of the typical farm is shown in Table 1. The typical farm, when compared with the whole township, is quite similar in percent of land devoted to each crop and yields per acre. However, the figures for all farms in the township in Table 1 include both rented and owned farms. Figures for all renters in the township are even more similar to those of the farm situation selected for study.

Description of Enterprises

The basic enterprises considered in this study are three crop rotations, three feeder cattle enterprises, two hog enterprises with spring and fall farrowings, dairy cows, and poultry. While numerous crop and livestock enterprises are available to crop-share tenants in central Iowa, only those enterprises that are typical of the area are considered. All enterprises compete freely for the use of resources, except poultry which competes only for capital.

Various resource restrictions are imposed on the enterprises for the resulting solutions so the effects of these restrictions can be observed. The resulting solutions give a range of alternative farm plans that are applicable to a

Table 1. Cropping history of typical farm and of Lee Township, Franklin County, Iowa[1]

Item	Typical farm 160 acres (1949-53 average)				Lee Township, all farms (1944-53 average)		
	Number of acres	Percent of total acres in crops	1949-53 yield/ acre actual	1944-53 10-year yield/ acre adjusted[a]	Total acres in:	Percent of total acres in crops	Yield/ acre actual
Corn	73	45.6	55.6	53.8	9,589	41.6	49.7
Soybeans	26	15.6	19.1	19.0	1,742	7.6	20.5
Oats	30	19.4	38.7	39.6	4,954	21.5	38.0
Hay	12	7.5			1,933	8.4	
Pasture	12	7.5			2,930	12.7	
Idle	0	0			145	0.6	
Buildings, lots, etc.	7	4.4			1,635	7.1	
Other land	0	0			123	0.5	
Total acres	160	100.0			23,051	100.0	

[1]Iowa Crop Reporting Service

[a]Adjusted on basis of 10-year average township yield.

variety of farm conditions, individual goals and resource supplies.

Crop enterprises

The feasible rotations for tenants who are beginning farmers in central Iowa are: corn-corn-oats-meadow rotation (CCOM), a corn-soybean-corn-oats-meadow rotation (CSbCOM), and a corn-corn-soybean rotation (CCSb).[1] The meadow in the first two is an alfalfa-red clover-timothy mixture. Four levels of fertilization are considered in this study for each rotation: (1) no fertilizer, (2) 30 pounds of available nitrogen, (3) 60 pounds of available nitrogen, and (4) 90 pounds of available nitrogen per acre (Table 2). In the remainder of this study rotations and fertilization levels will be indicated by the abbreviated form of the rotation followed by subscripts denoting fertilization levels. Hence, there are twelve crop alternatives.[2] The various levels of fertilization are

---

[1]Use of only three rotations does not mean that these are the only possible rotations for this area. The above rotations are the most typical and feasible for tenants. There are a large number of rotations that could have been included in the study, but they would have increased the computations of the study beyond manageable proportions.

[2](1) $CCOM_1$, (2) $CCOM_2$, (3) $CCOM_3$, (4) $CCOM_4$, (5) $CSbCOM_1$, (6) $CSbCOM_2$, (7) $CSbCOM_3$, (8) $CSbCOM_4$, (9) $CCSb_1$, (10) $CCSb_2$, (11) $CCSb_3$, (12) $CCSb_4$.

Table 2. Pounds per acre of available nutrients supplied by commercial fertilizer for different rotations and fertilization levels

Rotation	Fertilization levels											
	First			Second			Third			Fourth		
	N	P	K	N	P	K	N	P	K	N	P	K
Corn	0	0	0	5	20	10	10	50	20	40	60	20
Corn	0	0	0	30	20	10	60	25	20	80	30	20
Oats	0	0	0	10	20	0	15	20	0	20	35	30
Meadow	0	0	0	0	0	0	0	0	0	0	0	0
Corn	0	0	0	5	20	10	10	50	20	40	60	20
Soybeans	0	0	0	0	0	0	0	0	0	0	10	0
Corn	0	0	0	15	20	10	45	50	20	75	60	20
Oats	0	0	0	10	20	0	15	10	0	20	10	40
Meadow	0	0	0	0	0	0	0	0	0	0	0	0
Corn	0	0	0	15	20	10	45	50	20	75	60	20
Corn	0	0	0	30	20	10	50	25	20	70	30	20
Soybeans	0	0	0	0	0	0	0	0	0	0	20	0

included in the analysis in order to determine whether tenants with very limited capital should invest in fertilization or livestock. It is possible, because of the phenomenom of diminishing returns, that a beginning farmer strictly limited in capital may want to fertilize at a minimum level and invest the remainder of his funds in livestock. Or, if livestock prices are low, he may realize greater returns by investing more capital in fertilizers and less in livestock. The several levels of fertilization also allow consideration of heavy fertilization rates when the beginning farmer has sufficient capital. The decision of what portion of funds should be invested in rotation, per se, in fertilizers, or in livestock when the tenant has different units of capital, can be made when all crop and livestock enterprises are considered simultaneously.

Two levels of crop management are considered, average and above-average. Above-average crop management is considered for only a few plans in the latter part of this study; the main portion of this analysis considers average crop management. The difference between average and above-average crop management is in yields and timing and type of operations. With average crop management, less attention is given to timeliness of operations and other management practices such as insect and weed control, selection of corn varieties, and obtaining stands consistent with soil moisture and fertiliza-

tion levels. For above-average crop management the land is plowed when moisture conditions are just right; crops are planted and fertilizer applied exactly on time; cultivation is done when soil is not too wet; insects and weeds are effectively controlled; and more care is practiced in harvesting. Solutions are computed for techniques with above-average crop management to determine how these practices affect the investment allocation of limited funds in fertilization and rotations compared with livestock. Will the most profitable plan, generally, include different rotations, different levels of fertilization, and different combinations of enterprises when crop management is above average?

The nutrient combinations for the four fertilization levels and the corresponding crop yields for the two levels of crop management are given in Tables 2 and 3, respectively. Labor requirements for crops are shown in Table 5, page 20, in total amounts and by percentage distributions in months.

Livestock enterprises

Seven livestock enterprises are considered to be feasible for tenants who are beginning farmers on crop-share rented farms. Each livestock enterprise, except feeder cattle, is considered with both average and above-average levels of management. Feeder cattle are considered only with above-

Table 3. Estimated crop yields per acre for various fertilization levels and crop management on Clarion-Webster soils[1]

Rotation	Unit	Levels of management and fertilization[a]							
		Average management				Above-average management			
		Fertilization level				Fertilization level			
		1	2	3	4	1	2	3	4
Corn	bu.	58	65	67	68	58	67	72	75
Corn	bu.	48	54	57	59	48	57	62	65
Oats	bu.	32	38	41	43	32	39	43	45
Meadow	tons	1.9	2.2	2.4	2.5	1.9	2.2	2.4	2.5
Corn	bu.	58	65	67	68	58	66	70	73
Soybeans	bu.	20	22	24	25	20	22	24	25
Corn	bu.	50	56	59	61	50	59	64	67
Oats	bu.	32	38	41	43	32	39	43	45
Meadow	tons	1.9	2.2	2.4	2.5	1.9	2.2	2.4	2.5
Corn	bu.	40	50	57	59	40	53	61	65
Corn	bu.	32	42	49	51	32	45	53	57
Soybeans	bu.	19	21	23	24	19	21	23	24

[1]Iowa State College Agronomy Department. Unpublished research. Ames, Iowa, 1955.

[a]Assumptions:

1) Rotations and treatments have been in effect since at least 1925-30.

2) Yields are 10-year average yield estimate for period 1955-65 assuming normal weather conditions.

3) Soil is typically low in phosphorus, medium in potassium and medium in nitrogen soil test.

average management because of the risks and uncertainty associated with feeding cattle. Two levels of livestock management are considered in order to determine how farm plans differ for beginning farmers who have different managerial abilities for different types of livestock. In this study management is expressed in terms of feeding efficiency and the type and amount of products sold per animal or litter.[1] Other management factors such as disease control, death loss, and farrowing dates also are considered. While several gradations of management can be found in a sample of farms, only the two arbitrary levels are considered here. The basic livestock enterprises with resource requirements, summarized in Table 4, are:

Dairy with average management. This dairy enterprise includes cows with average productive capacity whose annual production consists of 228 pounds of butterfat, 4,569 pounds of skim milk, and the meat sold as beef. The productive life of each cow is 4 to 5 years. Annual replacement stock for each cow include the equivalent of one-third of a calf, one-third of a 1-year old, and one-fourth of a 2-year old. Total feed, capital, labor, building requirements (shown in Table 4), and

---

[1]The author does not propose that management can be completely defined on the basis of technical efficiency or individual preferences alone. However, in this study management will be used as defined above.

Table 4. Production and resource requirements for livestock enterprises for different levels of management[a]

Livestock enterprise and management level	Production per head or litter (lbs. or doz.)	Resource requirements				
		Corn (bu.)	Hay (lbs.)	Capital[b] ($)	Labor (hrs.)	Building space (sq.ft.)
Dairy						
Average	6,000.0	44.0	12,956.0	236.00	124.0	84.0
Above-average	9,430.0	66.0	13,672.0	311.00	129.0	84.0
Spring litters						
Average	1,524.0	119.0	1,437.0	162.00	26.0	38.6
Above-average	1,675.0	97.0	1,393.0	187.00	26.0	43.0
Fall litters						
Average	1,528.0	131.0	0	168.00	33.0	63.5
Above-average	1,677.0	106.0	0	187.00	33.0	70.0
Poultry						
Average	15.0	1.6	0	4.00	2.1	4.1
Above-average	19.2	1.7	0	4.20	2.1	4.1
Medium yearlings (drylot)						
Above-average	287.0	33.0	1,338.0	148.00	13.7	0
Choice calves (drylot)						
Above-average	550.0	61.0	1,409.0	139.00	17.4	0
Choice calves (pasture)						
Above-average	560.0	50.0	3,206.0	138.00	18.7	0

[a]A more complete description of the basic data for each enterprise is given in the Appendix.

[b]Included are (1) annual cash expenses such as feed supplements, breeding and veterinary fees, insurance, depreciation on investment, and purchase price of basic stock for beef and poultry; and (2) investment such as equipment for basic stock for hogs and dairy.

the net return for this enterprise are calculated on the basis of one cow and replacement stock.

Dairy with above-average management. This dairy enterprise includes cows with above-average productive capacity. Total annual production includes 9,430 pounds of milk per cow sold as grade A milk, and the meat sold as beef. The productive life of each cow is 4 to 5 years. Total feed, capital, labor, and building requirements (shown in Table 4) are based on one cow and replacements which include the equivalent of one-third of a calf, one-third of a 1-year old, and one-fourth of a 2-year old. Net return for this enterprise is also calculated on the basis of one cow and replacement stock.

Spring hogs with average management. This hog system includes pigs farrowed in April, fed out on pasture, and marketed in October at a weight of 225 pounds. Litters averaging 6.8 pigs weaned per sow but one gilt is saved back for farrowing the following year. Pork sold per litter, including a 300 pound sow, averages 1,524 pounds. The death loss is estimated at 5 percent after weaning. Total feed, capital, labor, building requirements (shown in Table 4), and net return for this enterprise are calculated on the basis of one sow and litter.

Spring hogs with above-average management. This hog system includes pigs farrowed in March, fed out on pasture,

and marketed in September at a weight of 225 pounds. Litters average 7.3 pigs weaned per sow but one gilt is saved back for farrowing the following year. Pork sold per litter, including a 300 pound sow, averages 1,675 pounds. The death loss is estimated at 3 percent after weaning. Total feed, capital, labor, building requirements (shown in Table 4), and net return for this enterprise are calculated on the basis of one sow and litter.

Fall hogs with average management. This hog system includes fall pigs farrowed in October, fed out in the drylot, and marketed in April at a weight of 225 pounds. Sows farrow two litters and are sold after fall farrowings. Litters average 6.7 pigs weaned per sow. Pork sold per litter, including 100 pounds of sow, averages 1,528 pounds. The death loss is estimated at 5 percent after weaning. Total feed, capital, labor, building requirements (shown in Table 4), and net return for this enterprise are calculated on the basis of one sow and litter.

Fall hogs with above-average management. This hog system includes fall pigs farrowed in September, fed out in the drylot, and marketed in March at a weight of 225 pounds. Sows farrow two litters and are sold after fall farrowings. Litters average 7.2 pigs weaned per sow. Pork sold per litter, including 100 pounds of sow, averages 1,677 pounds. Death loss is estimated at 3 percent after weaning. Total

feed, capital, labor, building requirements (shown in Table 4), and net return for this enterprise are calculated on the basis of one sow and litter.

Poultry with average management. This enterprise is a supplementary farm laying flock and is replaced with new stock each year. It does not compete with other enterprises for the limited resources except for capital and is supplementary in the use of labor. The annual egg production per hen is 180 eggs. An average of 1.25 sexed chicks per hen must be purchased each year for potential layers. Culling and mortality rates for hens are estimated at 11 percent and 15 percent of the total, respectively; chick mortality is estimated at 10 percent of the total. The resource requirements (shown in Table 4) and net return for this enterprise are based upon one hen and 1.25 sexed chicks.

Poultry with above-average management. This enterprise is a supplementary farm laying flock and is replaced with new stock each year. It does not compete with other enterprises for the limited resources except for capital and is supplementary in the use of labor. The annual egg production per hen is 230 eggs. An average of 1.25 sexed chicks per hen must be purchased each year for potential layers. Culling and mortality rates for hens are estimated at 11 percent and 15 percent of the total, respectively; chick mortality is estimated at 10 percent of the total. The resources require-

ments (shown in Table 4) and net return for this enterprise are based upon one hen and 1.25 sexed chicks.

Yearling steers fed on drylot with above-average management. With this enterprise medium yearling feeder steers are purchased in November weighing about 670 pounds, wintered primarily on roughage, and put on full feed in late winter. They are fed out in the drylot to grade good and marketed in April or May. Market weight averages 957 pounds per head and death loss is 1.5 percent. The resource requirements (shown in Table 4) and net return for this enterprise are calculated on a head basis.

Feeder calves fed on drylot with above-average management. With this enterprise good to choice feeder calves are bought in October weighing about 430 pounds, wintered on roughage and limited grain, and put on full feed in early summer. These calves are fed out to grade choice and marketed in August. Market weight averages 980 pounds per head and death loss is 2.5 percent. The resource requirements (shown in Table 4) and net return for this enterprise are calculated on a head basis.

Feeder calves fed on pasture with above-average management. With this enterprise good to choice calves are purchased in October weighing about 430 pounds, wintered on roughage and limited grain, and put on full feed on pasture the following spring. They are fed out to grade choice and

marketed in September. Market weight averages 990 pounds per head and death loss is 2.5 percent. The resource requirements (shown in Table 4) and net return for this enterprise are calculated on a head basis.

Production and resource requirements per head or litter for the livestock enterprises outlined above are included in Table 4. Labor requirements for crops and livestock are given in Table 5 in total amounts and by percentage distribution in months. The labor data are averages and the exact number of hours may vary on particular farms. However, the percentage distribution throughout the year is relatively constant for a given technique.

Table 5. Labor requirements for crops and livestock

Livestock enterprise and management level	Unit level	Total man hrs./yr.	Percent distribution by months					
			Jan.	Feb.	Mar.	Apr.	May	June
Dairy[1]								
Average	head	124.0	11.0	10.5	11.0	9.5	7.5	6.0
Above-average	head	129.0	11.0	10.5	11.0	9.5	7.5	6.0
Spring hogs[2]								
Average	litter	26.0	7.9	7.9	9.5	10.0	9.1	8.3
Above average	litter	26.0	5.7	5.7	23.0	5.8	5.8	8.3
Fall hogs[3]								
Average	litter	33.0	9.7	7.6	7.0	5.4	4.7	5.2
Above average	litter	33.0	8.3	6.5	12.2	6.5	6.5	5.7
Feeder cattle[3]								
Med. yearlings (drylot)	head	13.7	15.4	15.4	15.4	15.4	7.7	
Ch. calves (drylot)	head	17.4	5.8	5.7	5.7	8.0	14.4	14.4
Ch. calves (pasture)	head	18.7	5.8	5.7	5.7	8.0	13.0	13.0

[1]Adapted from Gilson, James C., Optimum livestock production under varying resource and price-cost situations in northeast Iowa, Unpublished Ph.D. Thesis, Ames, Iowa, Iowa State College Library, 1954.

[2]Adapted from An appraisal of agricultural production capacity in Iowa, Iowa State College, Iowa Agr. Ext. Bul. AN-153, 1952.

[3]Adapted from Heady, E. O. and Olsen, R. O., Substitution relationships, resource requirements and income variability in the utilization of forage crops, Iowa Agr. Exp. Sta. Bul. 390, 1952.

Table 5. (Continued)

Livestock enterprise and management level	Unit level	Total man hrs./yr.	Percent distribution by months					
			Jan.	Feb.	Mar.	Apr.	May	June
Crops[4]								
Corn	acre	7.0				11.8	22.0	13.1
Soybeans	acre	6.0				10.0	24.0	15.0
Oats	acre	6.0			7.1	17.9		
Meadow	acre	11.6						38.9
			July	Aug.	Sept.	Oct.	Nov.	Dec.
Dairy								
Average	head	124.0	6.0	6.5	6.0	7.5	8.5	10.0
Above-average	head	129.0	6.0	6.5	6.0	7.5	8.5	10.0
Spring hogs								
Average	litter	26.0	8.3	8.3	7.9	7.9	7.8	7.1
Above average	litter	26.0	8.3	6.5	12.2	6.5	6.5	5.7
Fall hogs								
Average	litter	33.0	5.0	8.2	13.0	12.4	10.9	10.9
Above average	litter	33.0	5.7	5.7	23.0	5.8	5.8	8.3
Feeder cattle								
Med. yearlings (drylot)	head	13.7					15.4	15.4
Ch. calves (drylot)	head	17.4	14.4	14.4		5.7	5.7	5.8
Ch. calves (pasture)	head	18.7	13.0	13.0	5.7	5.7	5.7	5.8

[4]Adapted from Bowlen, Bernard J., Production planning of crops for Iowa farms - using activity analysis and linear programming, Unpublished Ph.D. Thesis, Ames, Iowa, Iowa State College Library, 1954.

Table 5. (Continued)

Livestock enterprise and management level	Unit level	Total man hrs./yr.	Percent distribution by months					
			July	Aug.	Sept.	Oct.	Nov.	Dec.
Crops								
Corn	acre	7.0	10.7		2.0	14.8	20.4	5.2
Soybeans	acre	6.0	11.0		3.0	31.0	6.0	
Oats	acre	6.0	37.5	37.5				
Meadow	acre	11.6	33.1		28.0			

ANALYTICAL TECHNIQUE USED

The analytical technique used in this study is linear programming. The logic and technique for this method of analysis have been presented in several previous writings.[1] Therefore, only statements about its application to farm planning are included in this study.

Application of Linear Programming

The objective of a farm when viewed as a business unit is not to maximize net returns to any particular enterprise but rather to maximize, for the family as a whole, income from a given stock of resources. Since scarce resources are available to the farm family, some analytical framework is needed whereby an approximation can be made of the returns from alternative uses of these resources.

---

[1]Dorfman, Robert. Application of linear programming to the theory of the firm. Berkeley and Los Angeles, University of California Press, 1952, pp. 24-44, 79-94; Bowlen, Bernard J. Production planning of crops for Iowa farms--using activity analysis and linear programming. Unpublished Ph.D. thesis. Ames, Iowa, Iowa State College Library, 1954. pp. 27-58; Gilson, James C. Optimum livestock production under varying resource and price-cost situations in northeast Iowa--an application of linear programming. Unpublished Ph.D. thesis. Ames, Iowa, Iowa State College Library, 1954. pp. 12-28; Heady, Earl O. Simplified presentation and logical aspects of linear programming technique. Jour. Farm Econ. 34:1035-1048. 1954.

Linear programming, as an analytical tool, is very useful in farm planning as it can provide the basis for decision making. It is a mathematical technique that permits the simultaneous consideration of many hundreds of possible plans regarding the practice estimates or input-output coefficients and prices used. It allows specification of the most profitable plan with respect to capital, soil, labor, and other restrictions of the farm. These considerations are particularly important for beginning farmers who have limited funds and a multitude of opportunities for investing their limited funds. Other studies have shown the advantages of using linear programming in analyzing farm management problems.[1] Since linear programming simultaneously considers all possible crop and livestock combinations, farm practices, and resource limitations, it has, therefore, great usefulness as a farm planning technique. In this study linear programming is used to determine income possibilities and optimum farm plans for young farmers on crop-share rented farms from the

---

[1]McKee, Dean, et al. Optimum allocation of resources between pasture improvement and other opportunities within southern Iowa farms. Iowa Agr. Exp. Sta. Res. Bul. 435. 1956; Heady, Earl O. and Gilson, James C. Optimum combination of livestock enterprises and management practices on farms including dairying. Iowa Agr. Exp. Sta. Res. Bul. 437. 1956; Peterson, G. S. Selection of maximum profit combination of livestock enterprises and crop rotations. Jour. Farm Econ. 34:546-554. 1955.

standpoint of the tenant. Optimum plans for a landlord or owner of the same soil and farm situation might be quite different. However, linear programming methods also would allow selection of the most profitable plan under these circumstances with consideration given to soil types, capital availability, building space, labor distribution, and other limiting resource supplies.

Formulation of Activities

Within the framework of a linear model, each manner in which production is carried out is considered as a distinct activity or process, where each output, single or combined, is contingent upon a given cost or amount of inputs used. Thus, consideration of all possible combinations of enterprises by the linear programming technique requires that each possible way of producing livestock and crops be expressed as an activity. According to Dorfman, any productive process may be used at any positive level consistent with the supply of available resources. The consumption of resources and the total output are proportional to the level at which the activity is used. The consumption of each resource is the sum of the consumption of all activities and the total production is the sum of the outputs of each activity.[1] Within this frame-

---

[1]Dorfman, op. cit., p. 18.

work the productive problem becomes the problem of choosing which productive processes to use and the level at which to use each of them.

In this study there are a total of 72 separate activities or investment opportunities considered (Table 6). Linear programming is used to select the one combination of activities, among thousands of possible combinations, which will maximize returns under the different resource situations.

When crops are considered separately, there are a total of 12 crop activities. For example, a CCOM rotation with no application of fertilizer is an activity differing from the same rotation fertilized at a second, third, or fourth level. Since the input-output relationships for a rotation are considered in four ratios each crop rotation gives rise to four crop activities. Each crop activity in turn competes with all other activities for the use of available resources.

When crops are processed through livestock there are a total of 56 combined activities (Table 6). These combined activities are formed by tying livestock to the rotation. Since livestock production is limited to forage production, only combinations of livestock with CCOM and CSbCOM rotations are considered. Tying livestock to a rotation is accomplished by taking the hay equivalent produced per acre of rotation and dividing by the unit hay requirements for each livestock

Table 6. List of activities or enterprises included in study

Enterprise number	Enterprise	Type of rotation supplying feed[a]	Level of livestock management used
P_1	Dairy	$CCOM_1$	Average
P_2	Dairy	$CCOM_2$	Average
P_3	Dairy	$CCOM_3$	Average
P_4	Dairy	$CCOM_4$	Average
P_5	Dairy	$CSbCOM_1$	Average
P_6	Dairy	$CSbCOM_2$	Average
P_7	Dairy	$CSbCOM_3$	Average
P_8	Dairy	$CSbCOM_4$	Average
P_9	Dairy	$CCOM_1$	Above-average
P_{10}	Dairy	$CCOM_2$	Above-average
P_{11}	Dairy	$CCOM_3$	Above-average
P_{12}	Dairy	$CCOM_4$	Above-average
P_{13}	Dairy	$CSbCOM_1$	Above-average
P_{14}	Dairy	$CSbCOM_2$	Above-average
P_{15}	Dairy	$CSbCOM_3$	Above-average
P_{16}	Dairy	$CSbCOM_4$	Above-average
P_{17}	Spring-farrowed hogs	$CCOM_1$	Average
P_{18}	Spring-farrowed hogs	$CCOM_2$	Average
P_{19}	Spring-farrowed hogs	$CCOM_3$	Average
P_{20}	Spring-farrowed hogs	$CCOM_4$	Average
P_{21}	Spring-farrowed hogs	$CSbCOM_1$	Average
P_{22}	Spring-farrowed hogs	$CSbCOM_2$	Average
P_{23}	Spring-farrowed hogs	$CSbCOM_3$	Average
P_{24}	Spring-farrowed hogs	$CSbCOM_4$	Average
P_{25}	Spring-farrowed hogs	$CCOM_1$	Above-average
P_{26}	Spring-farrowed hogs	$CCOM_2$	Above-average
P_{27}	Spring-farrowed hogs	$CCOM_3$	Above-average
P_{28}	Spring-farrowed hogs	$CCOM_4$	Above-average
P_{29}	Spring-farrowed hogs	$CSbCOM_1$	Above-average
P_{30}	Spring-farrowed hogs	$CSbCOM_2$	Above-average

[a]The subscripts following the abbreviated form of rotations refers to the level of fertilization.

Table 6. (Continued)

Enterprise number	Enterprise	Type of rotation supplying feed	Level of livestock management used
P_{31}	Spring-farrowed hogs	$CSbCOM_3$	Above-average
P_{32}	Spring-farrowed hogs	$CSbCOM_4$	Above-average
P_{33}	Medium yearlings fed in drylot	$CCOM_1$	Above-average
P_{34}	Medium yearlings fed in drylot	$CCOM_2$	Above-average
P_{35}	Medium yearlings fed in drylot	$CCOM_3$	Above-average
P_{36}	Medium yearlings fed in drylot	$CCOM_4$	Above-average
P_{37}	Medium yearlings fed in drylot	$CSbCOM_1$	Above-average
P_{38}	Medium yearlings fed in drylot	$CSbCOM_2$	Above-average
P_{39}	Medium yearlings fed in drylot	$CSbCOM_3$	Above-average
P_{40}	Medium yearlings fed in drylot	$CSbCOM_4$	Above-average
P_{41}	Choice calves fed on pasture	$CCOM_1$	Above-average
P_{42}	Choice calves fed on pasture	$CCOM_2$	Above-average
P_{43}	Choice calves fed on pasture	$CCOM_3$	Above-average
P_{44}	Choice calves fed on pasture	$CCOM_4$	Above-average
P_{45}	Choice calves fed on pasture	$CSbCOM_1$	Above-average
P_{46}	Choice calves fed on pasture	$CSbCOM_2$	Above-average
P_{47}	Choice calves fed on pasture	$CSbCOM_3$	Above-average
P_{48}	Choice calves fed on pasture	$CSbCOM_4$	Above-average
P_{49}	Choice calves fed in drylot	$CCOM_1$	Above-average
P_{50}	Choice calves fed in drylot	$CCOM_2$	Above-average
P_{51}	Choice calves fed in drylot	$CCOM_3$	Above-average
P_{52}	Choice calves fed in drylot	$CCOM_4$	Above-average
P_{53}	Choice calves fed in drylot	$CSbCOM_1$	Above-average
P_{54}	Choice calves fed in drylot	$CSbCOM_2$	Above-average
P_{55}	Choice calves fed in drylot	$CSbCOM_3$	Above-average
P_{56}	Choice calves fed in drylot	$CSbCOM_4$	Above-average
P_{57}	Poultry		Average
P_{58}	Poultry		Above-average
P_{59}	Fall-farrowed hogs		Average
P_{60}	Fall-farrowed hogs		Above-average

Table 6. (Continued)

Enterprise number	Enterprise	Type of rotation supplying feed	Level of livestock management used
P_{61}	$CCOM_1$ grain sold for cash		
P_{62}	$CCOM_2$ grain sold for cash		
P_{63}	$CCOM_3$ grain sold for cash		
P_{64}	$CCOM_4$ grain sold for cash		
P_{65}	$CSbCOM_1$ grain sold for cash		
P_{66}	$CSbCOM_2$ grain sold for cash		
P_{67}	$CSbCOM_3$ grain sold for cash		
P_{68}	$CSbCOM_4$ grain sold for cash		
P_{69}	$CCSb_1$ entire production sold		
P_{70}	$CCSb_2$ entire production sold		
P_{71}	$CCSb_3$ entire production sold		
P_{72}	$CCSb_4$ entire production sold		

enterprise.[1] This division gives the number of possible livestock units (Table 7) that can be produced with each acre of

[1]An alternative method of considering all possible combinations livestock and crops simultaneously is to treat each crop rotation and livestock enterprise as independent activities. In this method, the grain and hay coefficients (a_{ij}) for livestock have a positive sign while they are negative for crop rotations. Hence, when crop activities are brought into the plan, the grain supply is increased; whereas the grain supply is decreased when livestock activities enter the plan. For a more detailed description of this method, see Peterson, G. A. Selection of maximum profit combinations of livestock enterprises and crop rotations. Jour. Farm Econ. 34:546-554. 1955.

Table 7. Production, net price and resource requirements for each activity

Item	Unit	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8
Units of output marketed[a]		4.40[b]	5.09[b]	5.56[b]	5.79[b]	3.52[b]	4.07[b]	4.45[b]	4.63[b]
Net price/unit[a]	$	12.18	14.33	14.91	14.40	12.26	14.75	15.59	15.26
Capital	$	34.25	39.25	42.69	45.35	30.65	34.43	37.35	39.67
Land	acre	1	1	1	1	1	1	1	1
Poultry housing	sq. ft.	0	0	0	0	0	0	0	0
Hog housing	sq. ft.	0	0	0	0	0	0	0	0
Dairy housing	sq. ft.	6.16	7.13	7.78	8.10	4.93	5.71	6.22	6.48
Operator labor:									
January	man-hrs.	1.00	1.16	1.26	1.32	.80	.93	1.01	1.05
February	man-hrs.	.95	1.11	1.21	1.26	.76	.88	.96	1.00
March	man-hrs.	1.09	1.25	1.35	1.40	.87	1.00	1.08	1.12
April	man-hrs.	1.50	1.71	1.80	1.85	1.32	1.49	1.56	1.59
May	man-hrs.	1.45	1.61	1.68	1.72	1.45	1.58	1.63	1.66
June	man-hrs.	1.74	1.87	1.93	1.96	1.57	1.68	1.72	1.75
July	man-hrs.	2.01	2.10	2.16	2.19	1.74	1.81	1.86	1.88
August	man-hrs.	1.06	1.15	1.22	1.25	.85	.92	.97	1.00
September	man-hrs.	1.14	1.23	1.29	1.31	.95	1.02	1.06	1.09
October	man-hrs.	1.20	1.31	1.38	1.42	1.33	1.42	1.48	1.50
November	man-hrs.	1.49	1.61	1.69	1.73	1.26	1.37	1.42	1.46
December	man-hrs.	1.09	1.23	1.33	1.38	.87	.99	1.06	1.10
Housewife labor (Feb.)	man-hrs.	0	0	0	0	0	0	0	0

[a]Forage, not consumed by livestock, goes unused. Net unit price includes sale of soybeans and grain sales or purchases.

[b]Hundred-pound units of milk.

Table 7. (Continued)

Item	Unit	P_9	P_{10}	P_{11}	P_{12}	P_{13}	P_{14}	P_{15}	P_{16}
Units of output marketed		6.55[b]	7.59[b]	8.28[b]	8.62[b]	5.24[b]	6.07[b]	6.62[b]	6.90[b]
Net price/unit	$	20.96	24.50	26.01	25.96	19.29	22.89	24.47	24.51
Capital	$	38.70	44.41	48.30	51.20	34.21	38.55	41.84	44.36
Land	acre	1	1	1	1	1	1	1	1
Poultry housing	sq. ft.	0	0	0	0	0	0	0	0
Hog housing	sq. ft.	0	0	0	0	0	0	0	0
Dairy housing	sq. ft.	5.84	6.76	7.37	7.68	4.67	5.41	5.90	6.14
Operator labor:									
January	man-hrs.	.99	1.14	1.25	1.30	.79	.91	1.00	1.04
February	man-hrs.	.94	1.09	1.19	1.24	.75	.87	.95	.99
March	man-hrs.	1.07	1.23	1.33	1.39	.86	.98	1.07	1.11
April	man-hrs.	1.49	1.68	1.79	1.83	1.31	1.48	1.55	1.59
May	man-hrs.	1.44	1.60	1.67	1.70	1.44	1.57	1.62	1.65
June	man-hrs.	1.79	1.93	1.98	2.01	1.61	1.72	1.77	1.79
July	man-hrs.	2.06	2.14	2.20	2.23	1.64	1.71	1.75	1.77
August	man-hrs.	1.05	1.14	1.20	1.24	.84	.91	.96	.99
September	man-hrs.	1.18	1.26	1.32	1.35	.98	1.05	1.09	1.11
October	man-hrs.	1.19	1.30	1.37	1.40	1.32	1.41	1.47	1.49
November	man-hrs.	1.48	1.60	1.68	1.72	1.25	1.34	1.41	1.45
December	man-hrs.	1.08	1.22	1.31	1.36	.86	.98	1.05	1.09
Housewife labor (Feb.)	man-hrs.	0	0	0	0	0	0	0	0

[b]Hundred-pound units of milk

Table 7. (Continued)

Item	Unit	P_{17}	P_{18}	P_{19}	P_{20}	P_{21}	P_{22}	P_{23}	P_{24}
Units of output marketed		10.07[c]	11.66[c]	12.73[c]	13.26[c]	8.06[c]	9.33[c]	10.18[c]	10.60[c]
Net price/unit	$	44.86	52.18	56.70	57.91	38.41	45.03	48.63	49.67
Capital	$	122.37	141.28	153.99	161.29	101.14	116.05	126.39	132.42
Land	acre	1	1	1	1	1	1	1	1
Poultry housing	sq. ft.	0	0	0	0	0	0	0	0
Hog housing	sq. ft.	25.54	29.58	32.26	33.61	20.43	23.66	25.81	26.89
Dairy housing	sq. ft.	0	0	0	0	0	0	0	0
Operator labor:									
January	man-hrs.	1.37	1.57	1.72	1.78	1.09	1.26	1.37	1.43
February	man-hrs.	1.36	1.57	1.72	1.78	1.09	1.26	1.37	1.43
March	man-hrs.	1.72	1.98	2.15	2.24	1.38	1.58	1.72	1.79
April	man-hrs.	2.36	2.70	2.88	2.97	2.00	2.28	2.43	4.50
May	man-hrs.	2.33	2.63	2.80	2.88	2.16	2.49	2.52	2.59
June	man-hrs.	1.94	2.21	2.36	2.44	1.73	1.95	2.07	2.13
July	man-hrs.	2.27	2.50	2.65	2.72	1.95	2.13	2.25	2.31
August	man-hrs.	1.90	2.12	2.27	2.35	1.52	1.70	1.82	1.88
September	man-hrs.	1.43	1.64	1.79	1.86	1.18	1.35	1.46	1.52
October	man-hrs.	1.88	2.09	2.23	2.30	1.87	2.04	2.16	2.22
November	man-hrs.	2.05	2.27	2.41	2.48	1.72	1.89	2.00	2.05
December	man-hrs.	1.40	1.60	1.72	1.79	1.12	1.28	1.38	1.43
Housewife labor (Feb.)	man-hrs.	0	0	0	0	0	0	0	0

[c]Hundred-pound units of pork.

Table 7. (Continued)

Item	Unit	P_{25}	P_{26}	P_{27}	P_{28}	P_{29}	P_{30}	P_{31}	P_{32}
Units of output marketed		11.42[c]	13.22[c]	14.42[c]	15.02[c]	9.13[c]	10.58[c]	11.54[c]	12.02[c]
Net price/unit	$	100.24	116.30	126.15	132.77	82.71	96.32	104.58	107.96
Capital	$	142.50	164.60	179.42	187.78	117.25	134.71	146.74	153.62
Land	acre	1	1	1	1	1	1	1	1
Poultry housing	sq. ft.	0	0	0	0	0	0	0	0
Hog housing	sq. ft.	29.09	33.68	36.74	38.27	23.27	26.74	29.39	30.62
Dairy housing	sq. ft.	0	0	0	0	0	0	0	0
Operator labor:									
January	man-hrs.	1.01	1.15	1.28	1.33	.81	.94	1.02	1.07
February	man-hrs.	1.01	1.15	1.28	1.33	.81	.94	1.02	1.07
March	man-hrs.	4.16	4.73	5.24	5.45	3.33	3.85	4.19	4.36
April	man-hrs.	1.66	1.88	2.01	2.06	1.45	1.64	1.73	1.77
May	man-hrs.	1.80	1.99	2.12	2.17	1.73	1.90	1.98	2.03
June	man-hrs.	1.98	2.23	2.42	2.49	1.76	1.99	2.11	2.18
July	man-hrs.	2.23	2.52	2.70	2.78	1.98	2.17	2.29	2.36
August	man-hrs.	1.62	1.78	1.92	1.98	1.30	1.44	1.54	1.59
September	man-hrs.	2.23	2.53	2.80	2.92	1.82	2.10	2.28	2.37
October	man-hrs.	1.67	1.83	1.97	2.03	1.71	1.85	1.95	2.00
November	man-hrs.	1.87	2.02	2.17	2.23	1.56	1.71	1.81	1.86
December	man-hrs.	1.19	1.33	1.46	1.51	.95	1.08	1.17	1.21
Housewife labor (Feb.)	man-hrs.	0	0	0	0	0	0	0	0

[c]Hundred-pound units of pork.

Table 7. (Continued)

Item	Unit	P_{33}	P_{34}	P_{35}	P_{36}	P_{37}	P_{38}	P_{39}	P_{40}
Units of output marketed		2.04[d]	2.36[d]	2.57[d]	2.68[d]	1.63[d]	1.89[d]	2.06[d]	2.15[d]
Net price/unit	$	19.54	22.86	24.21	24.08	18.15	21.57	23.03	23.01
Capital	$	123.21	142.26	155.05	162.40	101.81	116.84	127.24	133.31
Land	acre	1	1	1	1	1	1	1	1
Poultry housing	sq. ft.	0	0	0	0	0	0	0	0
Hog housing	sq. ft.	0	0	0	0	0	0	0	0
Dairy housing	sq. ft.	0	0	0	0	0	0	0	0
Operator labor:									
January	man-hrs.	1.49	1.73	1.88	1.96	1.19	1.38	1.51	1.57
February	man-hrs.	1.49	1.73	1.88	1.96	1.19	1.38	1.51	1.57
March	man-hrs.	1.58	1.82	1.97	2.05	1.26	1.45	1.58	1.64
April	man-hrs.	2.13	2.44	2.60	2.67	1.82	2.07	2.20	2.25
May	man-hrs.	1.52	1.68	1.76	1.80	1.50	1.63	1.70	1.73
June	man-hrs.	1.59	1.64	1.64	1.64	1.45	1.49	1.49	1.49
July	man-hrs.	1.81	1.81	1.81	1.81	1.58	1.58	1.58	1.58
August	man-hrs.	.47	.47	.47	.47	.38	.38	.38	.38
September	man-hrs.	.88	.88	.88	.88	.74	.74	.74	.74
October	man-hrs.	.52	.52	.52	.52	.79	.79	.79	.79
November	man-hrs.	2.21	2.44	2.60	2.68	1.84	2.02	2.15	2.21
December	man-hrs.	1.17	1.91	2.07	2.14	1.34	1.53	1.65	1.72
Housewife labor (Feb.)	man-hrs.	0	0	0	0	0	0	0	0

[d]Hundred-pound units of beef.

Table 7. (Continued)

Item	Unit	P_{41}	P_{42}	P_{43}	P_{44}	P_{45}	P_{46}	P_{47}	P_{48}
Units of output marketed		1.66[d]	1.92[d]	2.10[d]	2.18[d]	1.32[d]	1.54[d]	1.68[d]	1.75[d]
Net price/unit	$	21.44	25.06	26.62	26.59	19.67	23.33	24.96	25.01
Capital	$	57.45	66.11	71.99	75.87	49.20	55.92	60.79	64.09
Land	acre	1	1	1	1	1	1	1	1
Poultry housing	sq. ft.	0	0	0	0	0	0	0	0
Hog housing	sq. ft.	0	0	0	0	0	0	0	0
Dairy housing	sq. ft.	0	0	0	0	0	0	0	0
Operator labor:									
January	man-hrs.	.32	.37	.40	.42	.26	.30	.32	.34
February	man-hrs.	.32	.36	.40	.41	.25	.29	.32	.33
March	man-hrs.	.40	.45	.49	.50	.32	.36	.39	.40
April	man-hrs.	1.08	1.22	1.27	1.29	.98	1.10	1.14	1.15
May	man-hrs.	1.49	1.65	1.72	1.76	1.48	1.61	1.67	1.70
June	man-hrs.	1.80	1.95	2.03	2.06	1.62	1.75	1.81	1.84
July	man-hrs.	2.09	2.02	2.28	2.31	1.80	1.89	1.95	1.98
August	man-hrs.	1.18	1.30	1.37	1.41	.95	1.04	1.10	1.13
September	man-hrs.	.85	.90	.93	.95	.71	.76	.78	.80
October	man-hrs.	.83	.88	.92	.93	1.04	1.08	1.10	1.12
November	man-hrs.	1.03	1.08	1.11	1.13	.90	.93	.96	.97
December	man-hrs.	.50	.55	.59	.60	.40	.44	.47	.48
Housewife labor (Feb.)	man-hrs.	0	0	0	0	0	0	0	0

[d]Hundred-pound units of beef.

Table 7. (Continued)

Item	Unit	P_{49}	P_{50}	P_{51}	P_{52}	P_{53}	P_{54}	P_{55}	P_{56}
Units of output marketed		3.71[d]	4.29[d]	4.68[d]	4.88[d]	2.97[d]	3.44[d]	3.78[d]	3.90[d]
Net price/unit	$	29.53	34.42	36.83	37.23	26.14	30.82	33.13	33.52
Capital	$	111.59	128.81	140.38	147.11	92.52	106.07	115.50	121.08
Land	acre	1	1	1	1	1	1	1	1
Poultry housing	sq. ft.	0	0	0	0	0	0	0	0
Hog housing	sq. ft.	0	0	0	0	0	0	0	0
Dairy housing	sq. ft.	0	0	0	0	0	0	0	0
Operator labor:									
January	man-hrs.	.68	.79	.86	.90	.54	.63	.69	.72
February	man-hrs.	.67	.77	.84	.88	.54	.62	.68	.70
March	man-hrs.	.76	.86	.93	.97	.61	.69	.75	.77
April	man-hrs.	1.58	1.80	1.90	1.95	1.38	1.56	1.34	1.69
May	man-hrs.	2.46	2.78	2.95	3.04	2.26	2.51	2.65	2.72
June	man-hrs.	3.28	3.59	3.77	3.86	2.80	3.06	3.20	3.27
July	man-hrs.	3.50	3.76	3.94	4.03	2.93	3.14	3.28	3.35
August	man-hrs.	2.16	2.42	2.60	2.69	1.73	1.94	2.08	2.15
September	man-hrs.	.68	.88	.88	.88	.74	.74	.74	.74
October	man-hrs.	1.87	1.29	1.36	1.40	1.32	1.41	1.46	1.49
November	man-hrs.	1.38	1.49	1.56	1.59	1.18	1.26	1.32	1.35
December	man-hrs.	.86	.97	1.04	1.08	.69	.78	.83	.86
Housewife labor (Feb.)	man-hrs.	0	0	0	0	0	0	0	0

[d]Hundred-pound units of beef.

Table 7. (Continued)

Item	Unit	P_{57}	P_{58}	P_{59}	P_{60}	P_{61}	P_{62}	P_{63}	P_{64}
Units of output marketed		15.00[e]	191.70[e]	100.00[f]	100.00[f]	15.65[g]	17.73[g]	18.58[g]	19.10[g]
Net price/unit	$	.86	2.14	2.50	6.06	5.11	6.16	5.99	5.08
Capital	$	6.32	6.45	23.25	20.22	15.08	17.05	18.46	20.12
Land	acre	0	0	0	0	1	1	1	1
Poultry housing	sq. ft.	4.12	4.12	0	0	0	0	0	0
Hog housing	sq. ft.	0	0	4.15	4.18	0	0	0	0
Dairy housing	sq. ft.	0	0	0	0	0	0	0	0
Operator labor:									
January	man-hrs.	0	0	.21	.16	0	0	0	0
February	man-hrs.	0	0	.16	.13	0	0	0	0
March	man-hrs.	0	0	.15	.24	.09	.09	.09	.09
April	man-hrs.	0	0	.12	.13	.64	.71	.71	.71
May	man-hrs.	0	0	.10	.13	.77	.82	.82	.82
June	man-hrs.	0	0	.17	.11	1.19	1.24	1.24	1.24
July	man-hrs.	0	0	.11	.11	1.47	1.47	1.47	1.47
August	man-hrs.	0	0	.18	.11	.47	.47	.47	.47
September	man-hrs.	0	0	.28	.45	.60	.60	.60	.60
October	man-hrs.	0	0	.27	.11	.52	.52	.52	.52
November	man-hrs.	0	0	.24	.11	.71	.71	.71	.71
December	man-hrs.	0	0	.24	.16	.18	.18	.18	.18
Housewife labor (Feb.)	man-hrs.	.16	.16	0	0	0	0	0	0

[e]Dozen eggs.

[f]Hundred-pound units of pork.

[g]Bushels of corn equivalent.

Table 7. (Continued)

Item	Unit	P_{65}	P_{66}	P_{67}	P_{68}	P_{69}	P_{70}	P_{71}	P_{72}
Units of output marketed		12.72[g] 2.00[h]	14.38[g] 2.20[h]	15.06[g] 2.40[h]	15.48[g] 2.50[h]	12.00[g] 3.17[h]	15.33[g] 3.50[h]	17.67[g] 3.83[h]	18.33[g] 4.00[h]
Net price/unit	$	6.61	8.21	8.45	7.83	10.11	13.37	15.29	14.78
Capital	$	15.31	16.67	17.97	19.48	15.73	18.14	20.47	22.39
Land	acre	1	1	1	1	1	1	1	1
Poultry housing	sq. ft.	0	0	0	0	0	0	0	0
Hog housing	sq. ft.	0	0	0	0	0	0	0	0
Dairy housing	sq. ft.	0	0	0	0	0	0	0	0
Operator labor:									
January	man-hrs.	0	0	0	0	0	0	0	0
February	man-hrs.	0	0	0	0	0	0	0	0
March	man-hrs.	.07	.07	.07	.07	0	0	0	0
April	man-hrs.	.63	.69	.69	.69	.75	.75	.75	.75
May	man-hrs.	.90	.94	.94	.94	1.50	1.57	1.57	1.57
June	man-hrs.	1.13	1.17	1.17	1.17	.91	.98	.98	.98
July	man-hrs.	1.31	1.31	1.31	1.31	.72	.72	.72	.72
August	man-hrs.	.38	.38	.38	.38	0	0	0	0
September	man-hrs.	.51	.51	.51	.51	.15	.15	.15	.15
October	man-hrs.	.79	.79	.79	.79	1.31	1.31	1.31	1.31
November	man-hrs.	.64	.64	.64	.64	1.07	1.07	1.07	1.07
December	man-hrs.	.15	.15	.15	.15	.24	.24	.24	.24
Housewife labor (Feb.)	man-hrs.	0	0	0	0	0	0	0	0

[g]Bushels of corn equivalent.

[h]Bushels of soybeans.

rotation.[1] Then, by adding the input requirements for each acre of rotation and number of livestock units produced on that acre, the total requirements for the combined activities are obtained (Table 7).

Non-forage consuming livestock, such as fall hogs and poultry, are considered as independent activities. Grain for these enterprises is either purchased from the farm or the market. These enterprises, when considered at two levels of management, make up the remaining four of the 72 activities.

Units of output

The unit level of output of all activities is chosen arbitrarily with the inputs and unit prices stated in relation to this level of output. In this study, when crops are considered separately, the unit chosen is also one acre, but the outputs and inputs are now in terms of crops and livestock. The livestock units included in the combined activities are measured in hundredweights of animal products. The

---

[1]For example, the number of dairy units (100-pound milk units) that can be produced with the forage production from one acre of a COOM rotation fertilized at the second level (1,100 lbs.) is obtained by dividing total production of hay equivalent by the hay equivalent requirement for one dairy unit. This division $\left(\frac{1,100 \text{ lbs.}}{12,956/60}\right)$ gives 5.09 dairy units (Table 7).

output of pork is measured in terms of hundredweights of pork produced and marketed. With the spring-farrowing enterprise each 100 pounds of pork marketed includes 80 pounds of market hogs and 20 pounds of sow under average management and 82 pounds of market hog and 18 pounds of sow under above-average management. Dairy output units are in terms of 100-pound weights of milk marketed. Each 100-pound unit of milk marketed includes 100 pounds of milk, 58 pounds of beef and .66 pounds of veal under average management and 100 pounds of milk, 3.7 pounds of beef and .42 pounds of veal under above-average management. Beef output units are in terms of 100 pounds of beef produced. The output units for fall hogs and poultry are considered independently of crops. Each 100 pounds of pork marketed from the fall-farrowing enterprise includes 93 pounds of market hog and 7 pounds of sow under average management and 94 pounds of market hog and 6 pounds of sow under above-average management. A unit of output from the poultry enterprise includes 4.87 pounds of meat and 15 dozen eggs under average management and 4.87 pounds of meat and 19.17 dozen eggs under above-average management.

Having determined the units for measuring the output of each activity, the resource requirements are expressed in terms of these units. The resource requirements for each activity are presented in Table 7.

Linear Programming Restrictions

Plans on the following pages are restricted to the resources available to the tenant. The maximum profit plans thus relate to the tenant and his resources. Other plans would be most profitable to a landlord or owner for the same farm. The programming restrictions are indicated by equations (1) through (6) where S_1 is labor supply of the tenant family, S_2 is capital supply, S_3 is cropland, S_4 is building space, S_5 is grain produced or purchased, and S_6 is hay produced. In the following equations a_{1j} refers to the input-output coefficient of the particular enterprise for the resource indicated while x_{1j} refers to the amount of the enterprise using the resource. In all restrictions except for grain,

$$(1)\quad S_1 \geq \sum_{j=1}^{n} a_{1j}\, x_j \qquad (4)\quad S_4 \geq \sum_{j=1}^{n} a_{4j}\, x_j$$

$$(2)\quad S_2 \geq \sum_{j=1}^{n} a_{2j}\, x_j \qquad (5)\quad S_5 = \sum_{j=1}^{n} a_{5j}\, x_j$$

$$(3)\quad S_3 \geq \sum_{j=1}^{n} a_{3j}\, x_j \qquad (6)\quad S_6 \geq \sum_{j=1}^{n} a_{6j}\, x_j$$

production is limited to the resource supply, all of which need not be used in the plan. In the case of grain, however, the amount produced and purchased must be exhausted in the plan (either as feed or grain sales).

When capital is available, crop activities are permitted

to expand to the limit of the supply of land while livestock production is not permitted to exceed the forage production of the farm. When the corn and forage requirements for livestock are not in the same ratio as the production of corn and forage, any surplus forage will go unused while any surplus corn can be sold. Likewise, any deficit of corn can be purchased. A few plans, however, are computed with livestock production limited to the grain produced on the farm. The main portion of this study limits livestock production only to the supply of capital, labor, building space, and forage production of the farm.

Prices Used for Planning

Prices used in computing the optimum plans are included in Table 8. The pricing method used in this study attempts to maintain the average historical price relationships among the items purchased and the items sold by the farmer, while adjusting all prices to the 1954 price level. This adjustment is accomplished by taking the ratio of the average price of each item to the average price of corn for each period and multiplying this ratio by the 1954 price of corn. The period used for all items except hogs, feeder cattle, and milk products is 1950-54. The historical periods used to compute hog and feeder cattle prices are 1947-54 and 1935-54,

Table 8. Average adjusted prices used

Item	Unit	Purchase price	Selling price
Seed and fertilizer:			
Corn	bu.	11.50	--
Soybeans	bu.	4.30	--
Oats	bu.	1.00	--
Nitrogen (N)	lb.	.15	--
Phosphorus (P_2O_5)	lb.	.11	--
Potassium (K_2O)	lb.	.06	--
Feed and grain:			
Corn	bu.	1.43	1.43
Oats	bu.	.78	.78
Soybeans	bu.	--	2.74
Mixed hay	ton	17.40	--
Cattle supplement	cwt.	4.78	--
Hog supplement	cwt.	5.60	--
Laying mash	cwt.	4.92	--
Livestock and livestock products:			
Medium yearlings	cwt.	18.25	21.60
Choice feeder calves (drylot)	cwt.	24.10	25.77
Choice feeder calves (pasture)	cwt.	24.10	25.97
Cull dairy cow	cwt.	--	14.88
Veal calves	cwt.	--	21.87
Medium dairy cow	head	188.95	--
Good dairy cow	head	250.00	--
Butterfat	lb.	--	.61
Milk (3.7% Grade A)	cwt.	--	3.67
Sows	cwt.	19.47	17.70
March - market hogs	cwt.	--	20.41
April - market hogs	cwt.	--	19.90
September - market hogs	cwt.	--	21.96
October - market hogs	cwt.	--	20.07
Composite hog price[a]	cwt.	--	19.83

[a]Composite hog price is the weighted composite price per cwt. of fall pigs, spring pigs, and the sow.

Table 8. (Continued)

Item	Unit	Purchase price	Selling price
	1954 prices		
March - market hogs	cwt.	--	25.53
April - market hogs	cwt.	--	26.96
September - market hogs	cwt.	--	19.70
October - market hogs	cwt.	--	18.57
	1955 prices		
March - market hogs	cwt.	--	15.65
April - market hogs	cwt.	--	16.53
September - market hogs	cwt.	--	17.00
October - market hogs	cwt.	--	16.00

respectively. The prices used for Grade A milk and for butterfat represents an average price paid by dairy plants and creameries in Hardin County from March to December, 1954. The method of calculating adjusted prices is illustrated below:

$$\text{Average adjusted price of hogs} = \text{Average 1954 corn price} \times \frac{\text{Average hog price 1947-54}}{\text{Average corn price 1947-54}} .$$

The adjusted price by this method reflects the long term price relationships between commodities and corn as well as the 1954 general price level.

While the "average" prices used for the major calcula-

tions of this study are somewhat higher than those currently prevailing, they provide determination of plans to fit price relationships between products which are likely to exist over a period of years. The central problem in this study is to determine optimum farm organizations for farmers with different resource combinations. Hence, whether prices are high or low, the same farm organization will give maximum profits, as long as prices bear the same relationship to each other.

However, some solutions are computed where price ratios deviate from the adjusted long-run price ratio. To examine the effect on incomes of using higher or lower hog prices, 1954 and 1955 hog prices are used. Incomes are calculated under these price changes because an optimum plan for a given supply of resources depends on prices, as well as the input-output coefficients used. These price ratios also allow analysis of the income and farm organization problems which arise from price declines such as those faced by farmers in 1955.

Net prices are used in this study for calculation of optimum plans. The net unit price for all activities is the gross price for each activity minus the annual variable costs associated with the production of one unit of this activity. The gross price for each activity is computed by multiplying the various products produced per unit of this activity by

the individual product prices. The prices of all factors and products do not change throughout this study except in plans where hog prices were permitted to vary.

Capital and Management Levels and Costs

Capital is typically the most limiting resource for beginning farmers and the amount of capital possessed varies with individuals. Therefore, plans have been computed for different amounts of capital to determine how optimum plans differ with capital availability. The resulting plans indicate that the most profitable combination of crops and livestock enterprises should differ for specific amounts of capital on the same farm and soil type.

The six capital levels considered for planning are: $3,000, $5,000, $7,500, $10,000, $15,000, and capital not limiting. These capital levels represent capital available to the tenant for producing any of the numerous crop and livestock activities considered. These capital levels do not include the capital investment in machinery for crop production. The machinery investment for crop production has been treated as a fixed cost since a given amount must be owned by the tenant before the farm can be planted to any rotation. The machinery investment required by a crop-share tenant and other fixed costs are given in Table 9. These fixed costs

Table 9. Estimated fixed costs for tenant

Description of farm machinery	1954 value (new) ($)	Estimated life (years)	Annual depreciation ($)
Tractor - "3-bottom"	2,604	12	217.04
Plow - "3-bottom"	397	17	23.36
Tandem disc - "10-ft."	380	20	19.04
Corn planter - "4-row"	706	15	47.06
Fertilizer spreader - "10-ft."	268	6	44.75
Elevator - "50-ft."	700	15	46.67
Cultivator - "4-row"	539	12	44.94
Drag harrow - "24-ft."	186	15	12.42
2 flare box wagons	500	20	25.00
Manure spreader	514	10	51.40
Engate seeder	80	12	6.70
Pickup truck	1,800	10	180.00
Corn picker	1,879	12	313.12
Combine[a]			
Power mower - "7-ft."	298	12	24.85
Side delivery rake - "8-ft."	306	12	25.72
Total	11,159		1,082.07
Total personal property taxes and insurance for tenant (1.5% x $11,159)			167.39
Miscellaneous items:			
Electricity			30.00
Telephone			25.00
Farm papers			10.00
Farm organization dues			15.00
Estimated total fixed costs			1,329.46

[a]Tenant has the small grain and soybean crops custom harvested.

include depreciation and insurance on farm machinery as well as personal property taxes and other miscellaneous items. The profits for the resulting plans presented later suppose that fixed costs have been subtracted from gross revenue. Hence, the profit figures for each plan represent net income.

The $3,000 level was chosen as the minimum capital level because this amount is required for putting the entire farm into a rotation. The other five capital levels are chosen to determine optimum plans and how they change when capital is increased from this minimum level.[1] Since plans are expected to differ for beginning farmers with various managerial abilities, each of the six capital levels are considered with six combinations of livestock management. They are: (a) all activities with average management, (b) all livestock activities with above-average management, (c) hogs with above-average management (other activities average), (d) dairy with above-average management (other activities average), (e) feeder cattle with above-average management (other activities average), and (f) poultry with above-average management (other activities average). Feeder cattle

---

[1]In the alternative resource and price considerations examined later in the study, the $10,000 level of capital alone is used. This level is selected because capital is not the only limiting resource specifying the enterprises selected. Therefore, the farm plan is a function of all limiting resources rather than of land and capital alone, which is not the case for lower capital levels. With $10,000 capital each resource has an effect on the optimum farm plan.

are considered as investment opportunities in only (b) and (e).

The capital requirements (investment and operating expenses) for each enterprise are given in Tables 10 and 11. Annual cash expense for crops does not include the harvest cost for hay where hay is not harvested. Investment for crop production is zero since it is included under fixed machinery as shown in Table 9. The items included in annual cash expense for crops are such items as seed, fertilizer, insecticides, seed treatment, feed, and machinery repairs associated with crop production. Annual expense for livestock includes such items as fuel and repairs for livestock equipment, veterinary fees, insurance, replacement stock, and other miscellaneous expenses. Investment in livestock equipment is treated as a part of the capital investment, since it is not required unless livestock is included in a farm plan.

An interest charge has not been made for the capital used in computing plans in this study. If the capital used must be obtained from credit sources, income would be lowered by the corresponding interest charge.[1]

---

[1]Most young farmers will be using some borrowed capital. If the amount borrowed is $5,000 at 6 percent interest, the net profit of a particular plan will be $300 less than that shown. If the amount borrowed is $10,000, profits will be $600 less than that shown.

Table 10. Per acre cost of rotations with different levels of fertilization for a crop-share tenant on Clarion-Webster soil[1]

Rotation and fertilization level	Cost items			
	Constant costs[a] ($)	Fertilizer costs[b] ($)	Harvest costs[c] ($)	Total costs ($)
$CCOM_1$	11.98	0.00	5.92	17.90
$CCOM_2$	11.98	1.76	6.57	20.31
$CCOM_3$	11.98	3.10	6.95	22.03
$CCOM_4$	11.98	4.70	7.15	23.83
$CSbCOM_1$	12.25	0.00	5.31	17.56
$CSbCOM_2$	12.25	1.19	5.83	19.28
$CSbCOM_3$	12.25	2.25	6.14	20.81
$CSbCOM_4$	12.25	3.90	6.29	22.45
$CCSb_1$	13.25	0.00	2.48	15.73
$CCSb_2$	13.25	1.99	2.91	18.05
$CCSb_3$	13.25	4.00	3.22	20.47
$CCSb_4$	13.25	5.84	3.30	22.39

[1]Adapted from Bowlen, Bernard J. Production planning of crops for Iowa farms using activity analysis and linear programming. Unpublished Ph.D Thesis, Ames, Iowa, Iowa State College Library, 1954.

[a]Includes fuel, grease, repairs, maintenance of tractors and machinery, and one-half of the seed cost per acre.

[b]Includes only the tenant's share of the total cost.

[c]Includes only the tenant's share in the case of oats and soybeans but all harvest cost for corn. It was assumed that the tenant owned corn harvesting equipment but custom harvested the oats and soybeans.

Table 11. Capital requirements for livestock with different levels of management[a]

Livestock enterprise and management levels	Unit	Capital[b] (annual expense & capital investment) ($)
Dairy		
Average	100 lbs. milk[c]	3.97
Above-average	100 lbs. milk[d]	3.30
Spring hogs		
Average	100 lbs. pork marketed[e]	10.65
Above-average	100 lbs. pork marketed[f]	11.16
Fall hogs		
Average	100 lbs. pork marketed[g]	23.25
Above-average	100 lbs. pork marketed[h]	20.22

[a]A more complete description of the basic data for each enterprise is given in the Appendix.

[b]Includes (1) annual cash expenses such as feed supplements, breeding and veterinary fees, insurance, depreciation on investment and purchase price of basic stock for beef and poultry; and (2) investment such as equipment for basic stock for hogs and dairy.

[c]Unit output includes 100 pounds of milk, 5.8 pounds of beef and 166 pounds of veal.

[d]Unit output includes 100 pounds of milk, 3.7 pounds of beef and .42 pounds of veal.

[e]Unit output includes 80 pounds of market hog and 20 pounds of sow.

[f]Unit output includes 82 pounds of market hog and 18 pounds of sow.

[g]Unit output includes 93 pounds of market hog and 7 pounds of sow.

[h]Unit output includes 94 pounds of market hog and 6 pounds of sow.

Table 11. (Continued)

Livestock enterprise and management levels	Unit	Capital (annual expense & capital investment) ($)
Poultry		
Average	hen	6.32
Above-average	hen	6.45
Medium yearlings (drylot)		
Above-average	100 lbs. gain	51.68
Choice calves (drylot)		
Above-average	100 lbs. gain	25.27
Choice calves (pasture)		
Above-average	100 lbs. gain	24.60

ANALYSIS OF RESULTS

Optimum or profit maximizing plans are presented in this section. The method of presentation consists of separately analyzing each of the six livestock management situations for the six capital levels outlined earlier. When capital is very limiting, regardless of management level, optimum plans depend upon the amount of capital available. With capital not limiting, the extent to which production (and hence income) can be expanded depends upon managerial ability, as well as the supply of labor, livestock housing and other limiting resources. Therefore, beginning farmers with a very limited supply of capital must choose quite different farm plans than operators with a larger supply of capital if they wish to maximize profits. The importance of management in determining enterprise combination is directly related to capital availability.

All plans are computed with the restriction that production cannot exceed the resource supplies outlined earlier. If needed, grain can be purchased to expand livestock production beyond the grain produced on the farm. In the tables which follow the "corn surplus or corn deficit" column shows the bushels of corn which are bought or sold for each farm plan. A plus sign signifies corn sold while a minus sign indicates the number of bushels purchased. Where the number

of livestock units require more grain than is produced, a charge is made for the grain purchased. Thus, the price for the products produced is a net price.

Profits for the plans presented in the following tables suppose that fixed costs of $1,329 have been subtracted from gross revenue. Hence, the profit figures for each plan are given as net returns.

Optimum Plans with Average Management (Table 12)

A summary of the farm plans for the six capital levels with average management is given in Table 12. With $3,000 the most profitable plan (Plan 1) includes only crops. This plan includes 147 acres of CCSb fertilized at the third level. For this capital level, crop production and fertilization of crops give higher returns for small amounts of capital than do livestock. Some acres of land and some man hours of labor in all months are not used in this plan. Capital is the only limiting resource. Any attempt to plant more acres or to use more labor, with all other resources remaining constant, would lower profits. With only $3,000 (above machinery investment) no resource should be used for livestock. Thus, part of the answer to a question posed earlier (How does the amount of capital affect the optimum enterprise combination?) is already given. This question

Table 12. Optimum farm plans with average management on 160-acre Clarion-Webster, crop-share rented farm with different quantities of available capital

Plan	Capital level[a] ($)	Net return[b] ($)	Enterprises included in the farm plan	Crops	Acres	Limiting resources	Corn surplus or deficit (bu.)
1	3,000	911	147 acres $CCSb_3$	Corn	98	Capital	+2,589
				Soybeans	49		
2	5,000	1,598	135 acres $CCSb_3$	Corn	97	Capital	+1,257
			18 acres $CSbCOM_3$	Soybeans	48	Land	
			12 litters of spring hogs[c]	Oats	4		
				Meadow	4		
3	7,500	2,385	112 acres $CCSb_3$	Corn	91	Capital	- 679
			41 acres $CSbCOM_3$	Soybeans	46	Land	
			28 litters of spring hogs[c]	Oats	8		
				Meadow	8		
4	10,000	3,171	88 acres $CCSb_3$	Corn	85	Capital	-2,616
			65 acres $CSbCOM_3$	Soybeans	42	Land	
			43 litters of spring hogs[c]	Oats	13		
				Meadow	13		

[a]Capital above machinery investment of $11,159.

[b]Profits after fixed costs of $1,329 are subtracted.

[c]One litter includes a sow and 6.8 pigs weaned.

Table 12. (Continued)

Plan	Capital level ($)	Net return ($)	Enterprises included in the farm plan	Crops	Acres	Limiting resources	Corn surplus or deficit (bu.)
5	15,000	3,694	92 acres $CCSb_3$ 31 acres $CCOM_2$ 30 acres $CSbCOM_3$ 44 litters of spring hogs[c] 12 litters of fall hogs[d] 100 hens	Corn Soybeans Oats Meadow	89 36 14 14	Capital Land Poultry and hog housing October labor	-4,150
6	Capital not limiting (15,417)[e]	3,707	96 acres $CCSb_3$ 57 acres $CCOM_2$ 44 litters of spring hogs[d] 14 litters of fall hogs[d] 100 hens	Corn Soybeans Oats Meadow	93 32 14 14	Land Poultry and hog housing October labor	-4,394

[c]One litter includes a sow and 6.8 pigs weaned.

[d]One litter includes a sow and 6.7 pigs weaned.

[e]Amount of capital that can be used with a given supply of limiting resources listed in Column 7.

can be fully answered only after other capital and management levels have been considered. However, for this capital and management level, tenants can maximize profits by investing their limited capital in crop production rather than livestock. The 2,589 bushels of corn and 1,691 bushels of soybeans in Plan 1 are sold for cash. Profits for Plan 1, with fixed costs subtracted, are $911.

When capital is increased to $5,000 with average management, the most profitable plan (Plan 2) includes 135 acres of CCSb and 18 acres of CSbCOM rotations fertilized at the third level, 12 litters of spring hogs, and the cash sale of 1,257 bushels of grain and 561 bushels of soybeans. Profits for this plan, with fixed costs subtracted, are $1,598. The limiting resources for Plan 2 are land and capital. Increasing the quantity of capital allows some investment in livestock to be profitable. Investing funds in livestock at this capital level is more profitable than applying fertilizer at a rate higher than the third level on the CCSb and CSbCOM rotations. Since the hog system requires some pasture, 18 acres of the CSbCOM rotation are included in the plan. In practice, however, it would not be feasible to plant 18 acres of a second rotation just to obtain forage; the whole farm might be planted to a CCSb rotation with the necessary forage being supplied by a more permanent pasture involving alfalfa down for two years. In so doing, profits would be reduced

very little.

As capital is increased to $7,500 with average management, the number of spring litters is increased and the number of acres of CSbCOM rotation are correspondingly increased to provide the necessary forage for the hogs. Plan 3, with $7,500 includes 112 acres of CCSb and 41 acres of CSbCOM rotations fertilized at the third level, 28 litters of spring hogs, and the cash sale of 527 bushels of soybeans. Profits for this plan, with fixed costs subtracted, are $2,385. There is still not enough capital to profitably include poultry and dairy cows. The hog enterprise is increased beyond the hog house space because dairy cows cannot successfully compete for the limited capital. As a result of increasing the hog enterprise, grain production becomes insufficient to meet the requirements of 28 litters. Hence, 679 bushels of corn would have to be purchased. The limiting resources which specify the enterprises in Plan 3 are capital and land as labor is not limitational in any month.

With capital increased to $10,000, the spring hog enterprise is increased to the limit of the capital supply as building space is not limiting. Plan 4, with $10,000, includes 88 acres of CCSb and 65 acres of CSbCOM rotations fertilized at the third level, 43 litters of spring hogs, and the cash sale of 494 bushels of soybeans. Profits for this plan, with fixed costs subtracted, are $3,171. The higher

capital level allows an expansion in the number of spring hogs as this enterprise is limited only by capital. Acres of CSbCOM rotation are further substituted in the plan for acres of CCSb rotation to provide the necessary forage for the increased hog enterprise. Because spring hogs are successful in competing for the dairy barn space, dairy cows cannot be profitably included. Spring hogs in combination with crops give higher returns on limited capital than dairy cows or poultry. Of the 43 litters included in the plan, 30 litters are produced in the dairy barn. Expansion of the spring hog enterprise, however, increases the corn deficit as shown in Table 12. Nearly 2,600 bushels of corn will have to be purchased in Plan 4 to meet the feed requirements of 43 spring litters. However, some grain would be purchased with soybean receipts.

With a capital level of $15,000, October labor and building space become limiting. Fall hogs and poultry are included for the first time. The optimum plan (Plan 5) now includes 31 acres of CCOM rotation fertilized at the second level, 30 acres of CSbCOM and 92 acres of CCSb rotations fertilized at the third level, 44 litters of spring hogs, 12 litters of fall hogs, a supplementary laying flock of 100 hens, and the cash sale of 425 bushels of soybeans. In practice, farmers usually tend to keep away from more than two rotations in their farm plans, but it must be noted that three rotations

with the given livestock enterprises yield a maximum profit of $3,694 above fixed costs. A possible alternative plan, yielding only $32 less profits with the same livestock but including only CCSb and CCOM rotations, would probably be preferred by some farmers. The choice of this alternative plan, therefore, would depend upon individual preferences.

The limiting resources for Plan 5 are capital, land, October labor, and livestock housing. The greater amount of capital permits diversification of the crop and livestock programs. In previous plans capital was a major factor in determining the enterprises selected, whereas capital is now less important. October labor (the expansion of the fall hog enterprise requires a large amount of October labor for farrowing) and building space are now the major resource limitations specifying the enterprises selected. Consequently, fall hogs and poultry are included for the first time since capital is not exhausted by the spring hog enterprise (which is limited by building space). The greater amount of capital makes it profitable for some of the forage for the spring hog enterprise to be supplied by a CCOM rotation. Previously, forage was supplied by a CSbCOM rotation. Since the total livestock program is increased for this capital level, grain would have to be purchased. A total of 4,150 bushels of corn is needed to meet the grain requirements for this plan. However, some grain would be purchased with soybean receipts.

Plan 6, with capital not limiting, is not greatly different from the previous plan. The enterprises included are 96 acres of CCSb rotation fertilized at the third level, 57 acres of CCOM rotation fertilized at the second level, 44 litters of spring hogs, 14 litters of fall hogs, and the cash sale of 369 bushels of soybeans. Profits, with fixed costs subtracted, are $3,707. With the exception of capital, the limiting resources for this plan are the same as Plan 5. Only $417 of additional capital is used by making capital not limiting. Consequently, similar livestock enterprises are selected in Plans 5 and 6. Removing the capital limitation affects the selection of crop rotations more than livestock enterprises. Acres planted to a CSbCOM rotation in previous plans are now shifted to a CCOM rotation. The reason the CCOM rotation did not come into the optimum plans at capital levels lower than $15,000 is that other rotations give higher returns on capital, whereas the CCOM rotation utilizes labor more efficiently when capital is not limiting. Hence, beginning farmers with a very limited supply of capital would find it unprofitable to follow a high forage rotation since only a limited quantity of forage can be profitably marketed.

With capital not limiting, several alternative plans give almost equal profits. For example, one alternative plan includes 88 acres of CCSb and 65 acres of CSbCOM rotations fertilized at the third level, 44 litters of spring

hogs, 11 litters of fall hogs, and 100 hens. Net revenue for this plan is $3,679 or $28 less than for the optimum plan. However, the capital used for this plan is $14,046 while that used for the optimum plan is $15,417. The addition of $1,371 to the capital supply increased net revenue very little by changing the rotation and fertilization level and adding two fall litters. These results indicate that the returns on capital are approaching zero above $15,000 when the supply of other resources are constant. It is zero at $15,417, as indicated above in the optimum plan. For this reason, most operators would probably choose Plan 5 or the alternative plan above in preference to Plan 6, because the increased returns on capital are not sufficient to offset the risk involved in borrowing additional capital.

Plans vary with supply of capital

The six optimum plans outlined above for average management indicate that investment opportunities for beginning farmers vary with the supply of available capital. When capital is limited to $3,000, the farm plan includes only crops. Hence, young tenant operators with this amount of capital should invest their funds only in crops. Livestock can be profitably included only after additional capital is acquired. When capital is available in sufficient quantities,

thereby making other resources limitational, more flexibility in the choice of livestock and crops is possible. The beginning farmer, if he wishes to maximize profits, must plan according to his own resource limitations and individual goals. The existence of alternative farm plans, as indicated above, provides the opportunity for farmers to plan according to their own farm conditions. No one farm plan is best for all farmers on the same soil type, if they wish to maximize profits. The success of an educational program design to help young farmers choose farm plans consistent with their individual goasl and resource supplies depends upon the recognition of these facts.

Optimum Plans with Above-Average Livestock Management (Table 13)

The plans presented here consider tenants with above-average managerial ability. The resource restrictions are the same; only management is changed. Each plan with improved management and comparable capital levels are compared with the plans for average management to determine the effect of managerial ability on farm organization and income. A summary of the farm plans with above-average management is given in Table 13.

The optimum plan with $3,000 under improved management

Table 13. Optimum farm plans with above-average livestock management on 160-acre Clarion-Webster, crop-share rented farm with different quantities of available capital

Plan	Capital level[a] ($)	Net return[b] ($)	Enterprises included in the farm plan	Crops	Acres	Limiting resources	Corn surplus or deficit (bu.)
7	3,000	911	147 acres $CCSb_3$	Corn	98	Capital	+2,589
				Soybeans	49		
8	5,000	2,335	137 acres $CCSb_3$	Corn	98	Capital	+1,652
			16 acres $CSbCOM_2$	Soybeans	49	Land	
			10 litters of spring hogs[c]	Oats	3		
				Meadow	3		
9	7,500	4,108	115 acres $CCSb_3$	Corn	91	Capital	+ 246
			38 acres $CSbCOM_2$	Soybeans	46	Land	
			24 litters of spring hogs[c]	Oats	8		
				Meadow	8		
10	10,000	5,882	93 acres $CCSb_3$	Corn	86	Capital	-1,160
			60 acres $CSbCOM_2$	Soybeans	43	Land	
			38 litters of spring hogs[c]	Oats	12		
				Meadow	12		

[a]Capital above machinery investment of $11,159.

[b]Profits after fixed costs of $1,329 are subtracted.

[c]One litter includes a sow and 7.3 pigs weaned.

Table 13. (Continued)

Plan	Capital level ($)	Net return ($)	Enterprises included in the farm plan	Crops	Acres	Limiting resources	Corn surplus or deficit (bu.)
11	15,000	7,530	96 acres $CCSb_3$ 57 acres $CSbCOM_3$ 39 litters of spring hogs[c] 12 litters of fall hogs[d] 100 hens	Corn Soybeans Oats Meadow	87 44 11 11	Capital Land Poultry and hog housing	-2,669
12	Capital not limiting (19,113)[e]	8,747	98 acres $CCSb_3$ 15 acres $CCOM_2$ 40 acres $CSbCOM_3$ 39 litters of spring hogs[c] 24 litters of fall hogs[d] 100 hens	Corn Soybeans Oats Meadow	88 41 12 12	Land Poultry and hog housing March labor	-3,586

[c]One litter includes a sow and 7.3 pigs weaned.

[d]One litter includes a sow and 7.2 pigs weaned.

[e]Amount of capital that can be used with a given supply of limiting resources listed in Column 7.

(Plan 7) is the same as Plan 1 with average management. Crop production and some fertilization of crops gives higher returns for small amounts of capital than do livestock under both management situations. When capital is the limiting resource, managerial ability does not affect the choice of enterprises selected. Hence, the same recommendations are appropriate for young farmers with $3,000, regardless of their efficiency in livestock production.

With capital increased to $5,000 the cropping plan is changed to provide some forage for the livestock included. Plan 8 includes 137 acres of CCSb fertilized at the third level and 16 acres of CSbCOM rotation fertilized at the second level, 10 litters of spring hogs, and the cash sale of 559 bushels of soybeans and 1,652 bushels of corn.[1] Profits, with fixed costs subtracted, are $2,335. Similar crops and livestock are included in Plans 2 and 8, even though the management level is different. Fewer spring litters are included in the present plan because more capital is required per litter. The CSbCOM rotation in Plan 8 is now fertilized at the second level and fewer acres of meadow are included in this plan because less forage is needed for spring hogs. The

---

[1]Under actual farm conditions the farm would be planted to only a CCSb rotation with the necessary forage being supplied by permanent pasture. Such a plan would not reduce profits.

difference in net revenue for the two plans, $739, is primarily attributable to the level of swine management than to the fertilization level. Hence, regardless of the level of management proficiency in livestock production, the investment opportunities are practically the same. However, profits are higher for improved management due to greater feeding efficiency and pork production per litter. As a result of better feeding efficiency, more grain is sold for cash. Therefore, one possible way for young farmers to improve their income potential is by improving their management practices.

As capital is increased to $7,500 (Plan 9) the number of litters of spring hogs is increased. To provide the increased forage required by a larger hog enterprise, acres of $CSbCOM_2$ are substituted in the plan for $CCSb_3$. Plan 9 with $7,500 includes 115 acres of CCSb rotation fertilized at the third level and 38 acres of CSbCOM rotation fertilized at the second level, 24 litters of spring hogs, and the cash sale of 524 bushels of soybeans and 246 bushels of corn. Profits, with fixed costs subtracted, are $4,108. Similar results are obtained in Plan 3 (Table 12) with average management. The reason for obtaining similar plans, regardless of management proficiency, is that spring hogs give higher returns on capital than do either cattle or poultry.

When capital is increased to $10,000 the optimum plan (Plan 10) calls for 93 acres of CCSb rotation fertilized at

the third level and 60 acres of CSbCOM rotation fertilized at the second level, 38 litters of spring hogs, and the cash sale of 488 bushels of soybeans. Profits, with fixed costs subtracted, are $5,882. The limiting resources are the same as for Plan 9. Plan 10 includes only spring hogs with rotations because spring hogs are more profitable than all other livestock enterprises. Substitution of some CSbCOM rotation for some CCSb rotation is necessary to provide the necessary forage for the increased hog enterprise. The result of increasing the supply of capital from $7,500 to $10,000 causes the hog enterprise to expand and to increase the acres of forage produced. Increasing the hog enterprise makes it necessary to purchase 1,160 bushels of corn, but some would be purchased with soybean receipts. Grain purchases in Plan 10 are less than in Plan 4 (which contains similar livestock and crops) because fewer litters of hogs are included in Plan 10.

As capital is increased to $15,000, the cropping plan changes very little. However, the fertilization level and livestock enterprises are different. The CSbCOM rotation is now fertilized at the third level. In addition to the spring hog enterprise included in previous plans, the present plan now includes fall hogs and poultry. Plan 11, with $15,000, includes 96 acres of CCSb and 57 acres of CSbCOM rotations fertilized at the third level, 39 litters of spring hogs, 12

litters of fall hogs, a supplementary laying flock of 100 hens, and the cash sale of 505 bushels of soybeans. The limiting resources for this plan are capital, land, and building space for poultry and hogs. Labor is not limitational in any month and does not influence the selection of enterprises. Quite similar livestock enterprises are included in Plans 5 (Table 12) and 11, but the cropping system is different. The greater amount of the meadow comes into Plan 5 to provide the pasture for 44 litters of spring hogs. In both plans, the addition of fall hogs and poultry to the plan provides the best possible use of all the tenant's resources.

An alternative plan to Plan 11 includes the same livestock and crops except 20 acres of the CSbCOM rotation are now fertilizaed at the second level. The lower rate of fertilization reduces profits only seven dollars. This plan indicates that some variation in fertilization levels is possible without materially affecting the level of net income.

The optimum plan with capital not limiting (Plan 12) is not materially different from Plan 11, except for a larger fall hog enterprise. Adding $4,113 increases the fall hog enterprise by 12 litters and increases profits by $1,217. The returns on capital are still quite high, but more than $19,113 of capital cannot be profitably used as March labor and livestock housing limits further expansion of the hog enterprise. Similar rotations and livestock are included in

Plans 6 (Table 12) and 12, but the size of the farm business is much larger in Plan 12. The returns to capital are greater with above-average management, hence, more capital can be profitably employed. With the same quantity of fixed resources but different management proficiency, the income potential is almost two times as great for beginning operators with improved management. Therefore, the major factor determining the level of income for beginning farmers with a fixed supply of labor and livestock housing and capital not limiting is management.

Optimum Plans with Above-Average Management for Hogs--Other Activities Average (Table 14)

Previous plans were computed for situations where beginning operators have either average or above-average management ability. Optimum plans presented in this section consider tenants to have above-average management proficiency in swine production but average proficiency in all other activities. These plans are summarized in Table 14.

When capital is limited to $3,000 the optimum farm plan (Plan 13) includes 147 acres of CCSb rotation fertilized at the third level. Plan 13 is identical to Plans 1 and 7 (Tables 12 and 13) with all activities having average and above-average management, respectively. Hence, with $3,000,

Table 14. Optimum plans with above-average management for hogs (other activities average) on 160-acre Clarion-Webster, crop-share rented farm with different quantities of available capital

Plan	Capital level[a] ($)	Net return[b] ($)	Enterprises included in the farm plan	Crops	Acres	Limiting resources	Corn surplus or deficit (bu.)
13	3,000	911	147 acres $CCSb_3$	Corn	98	Capital	+2,589
				Soybeans	49		
14	5,000	2,335	137 acres $CCSb_3$	Corn	98	Capital	+1,652
			16 acres $CSbCOM_2$	Soybeans	49	Land	
			10 litters of spring hogs[c]	Oats	3		
				Meadow	3		
15	7,500	4,108	115 acres $CCSb_3$	Corn	91	Capital	+ 246
			38 acres $CSbCOM_2$	Soybeans	46	Land	
			24 litters of spring hogs[d]	Oats	8		
				Meadow	8		
16	10,000	5,882	93 acres $CCSb_3$	Corn	86	Capital	-1,160
			60 acres $CSbCOM_2$	Soybeans	43	Land	
			38 litters of spring hogs[c]	Oats	12		
				Meadow	12		

[a]Capital above machinery investment of $11,159.

[b]Profits after fixed costs of $1,329 are substracted.

[c]One litter includes a sow and 7.3 pigs weaned.

Table 14. (Continued)

Plan	Capital level ($)	Net return ($)	Enterprises included in the farm plan	Crops	Acres	Limiting resources	Corn surplus or deficit (bu.)
17	15,000	7,509	96 acres $CCSb_3$ 57 acres $CSbCOM_3$ 39 litters of spring hogs[c] 14 litters of fall hogs[d]	Corn Soybeans Oats	87 44 11	Capital Land Hog housing	-2,706
18	Capital not limiting (19,140)[e]	8,624	101 acres $CCSb_3$ 41 acres $CCOM_2$ 11 acres $CSbCOM_3$ 40 litters of spring hogs[c] 24 litters of fall hogs[d] 100 hens	Corn Soybeans Oats Meadow	93 36 12 12	Land Poultry and hog housing March labor September labor	-3,857

[c]One litter includes a sow and 7.3 pigs weaned.

[d]One litter includes a sow and 7.2 pigs weaned.

[e]Amount of capital that can be used with a given supply of limiting resources listed in Column 7.

tenants can maximize profits by investing limited funds in crops and fertilization of crops, regardless of the level of livestock management.

As capital is increased to $5,000, $7,500, and $10,000 for tenants with above-average managerial ability in hogs, the resulting farm plans are the same as obtained for comparable capital levels with all activities having above-average management. Spring hogs in combination with crops in Plans 8, 9, 10, 14, 15, and 16 offer beginning operators the most profitable investment opportunity. Therefore, similar recommendations would be appropriate for farmers having these specified resource quantities and management proficiency.

When capital is increased to $15,000 with above-average management only in hogs, the optimum plan (Plan 17) includes 96 acres of CCSb and 57 acres of CSbCOM rotations fertilized at the third level, 39 litters of spring hogs, 14 litters of fall hogs, and cash sale of 505 bushels of soybeans. Profits, with fixed costs subtracted, are $7,509. The limiting resources for this plan are capital, land, and hog housing. Labor is not limitational in any month. Similar enterprises were included in Plan 11 (Table 13) with above-average management for all activities. However, Plan 17 does not have a poultry enterprise and includes more fall litters. Substitution of two fall litters for 100 hens in Plan 17 is the result of considering poultry with average management. However, the dif-

ference in net income for these two plans is only $21. From the standpoint of actual farm planning, consideration of a poultry enterprise affects the optimum combination of livestock and crops very little. A choice between these two plans would depend upon the particular values of a farm family. Some families may want to have a supplementary poultry enterprise for home use or to reduce some of the income variability associated with specialization in hogs. Adding a poultry enterprise has little effect on profits but it does increase the applicability of these results to more farm situations.

An alternative plan to Plan 17 is one that includes the same livestock and cropping systems except the CSbCOM rotation is now fertilized at the second level. The difference in net revenue for these two plans, however, is only $23. The reduction in profits is small enough to suggest that for this capital level some flexibility in fertilization rates is possible without materially affecting net income.

The maximum profit plan, with capital not limiting and average management for all activities except hogs (Plan 18), includes 101 acres of CCSb and 11 acres of CSbCOM rotations fertilized at the third level, 41 acres of CCOM rotation fertilized at the second level, 40 litters of spring hogs, 24 litters of fall hogs, a supplementary laying flock of 100 hens, and the cash sale of 432 bushels of soybeans. Profits for Plan 18, with fixed costs subtracted, are $8,624. The

resources specifying the enterprises in this plan are land, March and September labor, and livestock housing. Hence, with capital not limiting a combination of spring and fall pigs with a supplementary poultry enterprise maximizes profits.

As pointed out earlier, the practice of following three rotations, as in Plan 18, is usually not feasible under actual farm conditions. A possible alternative to Plan 18 that might be preferred by some operators includes only two rotations, CCSb and CSbCOM, with the same livestock enterprises as the optimum plan. However, the combination of livestock enterprises now have been changed to include 34 litters of spring hogs, 29 litters of fall hogs, and a laying flock of 100 hens. Profits for this plan are only $46 less than optimum. Hence, these results suggest that, with capital not limiting, variations in both crop and livestock enterprises is possible without materially affecting profits. Some operators, seeking to spread price risks associated with a diversified hog program may prefer this alternative plan. Variation in enterprise combination makes it possible for young farmers to make short run adjustments to risks and uncertainty without loss of much income.

Optimum Plans with Above-Average Management for Dairy--Other Activities Average (Table 15)

In previous plans, dairying was not included since dairy cows could not successfully compete with spring hogs for capital and the dairy building space. However, when above-average management is assumed for dairying and average management is included for all other activities, dairy cows are included in some farm plans. Since dairy cows require more roughage than spring hogs, plans including dairy cows contain a greater amount of meadow. Therefore, for the first time some plans do not contain a CCSb rotation. The plans for the six capital levels, with only above-average management for dairying, are summarized in Table 15.

The optimum plan with above-average management for dairying (all other activities average) and $3,000 (Plan 19) includes only crops. Plan 19 is the same plan as all previous plans obtained with a comparable capital supply (Plans 1, 7, and 13). Proficiency in dairy management does not change the income opportunities of beginning farmers when capital is limited to $3,000. Crops production and fertilization of crops give higher returns for small amounts of capital than do livestock.

As capital is increased to $5,000 with above-average dairy management, some dairy cows are included in the farm

Table 15. Optimum plans with above-average management for dairy (other activities average) on 160-acre Clarion-Webster, crop-share rented farm with different quantities of available capital

Plan	Capital level[a] ($)	Net return[b] ($)	Enterprises included in the farm plan	Crops	Acres	Limiting resources	Corn surplus or deficit (bu.)
19	3,000	911	147 acres $CCSb_3$	Corn	98	Capital	+2,589
				Soybeans	49		
20	5,000	1,813	87 acres $CSbCOM_3$	Corn	79	Capital	+2,070
			66 acres $CCSb_3$	Soybeans	40	Land	
			6 dairy cows	Oats	17		
				Meadow	17		
21	7,500	2,729	153 acres $CSbCOM_3$	Corn	62	Capital	- 587
			19 litters of spring hogs[c]	Soybeans	31	Land	
				Oats	30		
			10 dairy cows	Meadow	30		
22	10,000	3,399	153 acres $CSbCOM_3$	Corn	62	Capital	-1,404
			26 litters of spring hogs[c]	Soybeans	31	Land	
				Oats	30	Dairy and hog housing	
			8 dairy cows	Meadow	30		
			48 hens				

[a]Capital above machinery investment of $11,159.

[b]Profits after fixed costs of $1,329 are subtracted.

[c]One litter includes a sow and 6.8 pigs weaned.

Table 15. (Continued)

Plan	Capital level ($)	Net return ($)	Enterprises included in the farm plan	Crops	Acres	Limiting resources	Corn surplus or deficit (bu.)
23	15,000	3,944	119 acres $CSbCOM_3$ 34 acres $CCOM_3$ 24 litters of spring hogs[c] 13 litters of fall hogs[d] 9 dairy cows 100 hens	Corn Soybeans Oats Meadow	65 24 32 32	Capital Land Dairy, poultry and hog housing October labor	-2,945
24	Capital not limiting (15,811)[e]	3,982	19 acres $CCSb_3$ 97 acres $CCOM_3$ 37 acres $CSbCOM_3$ 25 litters of spring hogs[c] 15 litters of fall hogs[d] 9 dairy cows 100 hens	Corn Soybeans Oats Meadow	76 13 32 32	Land Dairy, poultry and hog housing October labor	-3,043

[c]One litter includes a sow and 6.8 pigs weaned.

[d]One litter includes a sow and 6.7 pigs weaned.

[e]Amount of capital that can be used with a given supply of limiting resources listed in Column 7.

plan for the first time. Under the present management situation, dairy cows are successful in competing with spring hogs for both capital and dairy building space. The farm plan for $5,000 (Plan 20) includes 66 acres of CCSb and 87 acres of CSbCOM rotations fertilized at the third level, six dairy cows, and the cash sale of 461 bushels of soybeans and 2,070 bushels of corn. Profits, with fixed costs subtracted, are $1,813. For this plan, capital and land are the only limiting resources. Labor is not limitational in any month. The CCSb rotation is the first activity to come into the plan and expands to the limit of acres available. However, additional output and profits are possible by substituting some CSbCOM rotation for some CCSb rotation and adding dairy cows. Substitution of these rotations and adding dairy cows is carried on until the capital supply is exhausted. As the dairy enterprise is increased, the acres planted to a CSbCOM rotation are also increased to supply the necessary forage. The final plan includes a combination of crops and dairy cows giving greater returns on the scarce acres and capital than any other combination of enterprises. This plan differs from Plans 2, 8, and 14 (Tables 12, 13, and 14) both in the acres planted to rotations and in the type of livestock included. Plans previously computed, primarily included only spring pigs in combination with crops. In this instance where dairy cows are considered at above-average management, dairy cows are

more profitable than spring pigs with average management. Hence, for the first time, managerial ability influences the selection of the most profitable combination of enterprises. Beginning operators with above-average dairy management, but only average swine management, would maximize profits on limited capital by investing in dairy cows and crops.

As capital is increased to $7,500, the profit maximizing plan (Plan 21) differs considerably from the previous plan with $5,000. The farm plan now contains a different cropping system and a combination of livestock enterprises. Plan 21 includes 153 acres of CSbCOM rotation fertilized at the third level, 19 litters of spring hogs, 10 dairy cows, and the cash sale of 367 bushels of soybeans. Profits, with fixed costs subtracted, are $2,729. The limiting resources specifying the enterprises in this plan are capital and land. Labor is not limitational in any month. With above-average management for dairy and average swine management, dairy cows are not able to compete with spring hogs for all of the dairy building space. Sufficient capital is now available to expand the dairy enterprise to the limit of the dairy barn space (14 cows). However, profits can be further increased by reducing the dairy enterprise and adding spring hogs. When spring hogs are added to the plan, some of the acres devoted to forage production for the dairy activity are reallocated to spring hogs. As acres of rotation are shifted to forage

production for spring hogs, the dairy activity is reduced. Substitution of spring litters for dairy cows continues until the capital supply is exhausted. Hence, a combination of dairy cows with spring hogs gives higher returns on limited capital and land than does specialization in either livestock activity.

There are several alternative plans to Plan 21 which include different combinations of dairy cows and spring litters that give slightly less than maximum profits. In some cases the difference in profits between the optimum and alternative plan is very small. Since some operators may prefer an alternative plan that includes all dairy or spring hogs, these alternatives (profits for a plan with either all dairy cows or all spring hogs are $300 and $344, respectively, less than optimum) should be considered in farm planning. The beginning farmer, if he wishes to maximize profits, must plan according to his own conditions and resource limitations.

With a capital level of $10,000 and above-average dairy management, the profit maximizing plan includes the same enterprises as the previous plan, except the combination of livestock enterprises is modified to include a small poultry enterprise. The dairy enterprise is reduced while the spring hog activity is increased. Plan 22 includes 153 acres of CSbCOM rotation fertilized at the third level, eight dairy cows, 26 litters of spring hogs, 48 hens, and the cash sale

of 367 bushels of soybeans. Profits for this plan, with fixed costs subtracted, are $3,399. The limiting resources which specify the enterprises selected are capital, land, dairy, and hog housing. Spring hogs are increased in this plan as this enterprise can outbid the dairy cows for part of the dairy building space. Nearly 1,400 bushels of corn would have to be purchased in this plan because of the greater number of spring litters.

There are several alternative combinations of dairy cows and spring hogs that should be considered by young farmers. The combination outlined above is the one which actually maximizes profits for the resources considered. However, numerous others give returns almost as large and may be preferred by some operators. In some cases different combinations reduce profits very little. Choosing all dairy or all spring litters would not reduce profits by more than $200. Some of the alternative plans which give slightly less than maximum profits are:

Alternative Plan (1) includes 153 acres of CSbCOm rotation fertilized at the third level, one litter of fall hogs, 19 litters of spring hogs, and 10 dairy cows. Profits are $3,390.

Alternative Plan (2) includes 153 acres of CSbCOM rotation fertilized at the third level, 42 spring litters, and one dairy cow. Profits for this plan, with fixed costs

subtracted, are $3,194.

Thus, specializing in spring hogs reduces profits by about $200. For this capital and management level, beginning farmers have a variety of almost equally profitable plans to choose from. The existence of several almost equally profitable combinations of dairy cows and spring hogs makes the above optimum plan adaptable to a wide variety of farm conditions.

With a capital level of $15,000, October labor is also limiting (the expansion of the hog enterprise requires a large amount of October labor for farrowing). A fall hog activity is now included in the plan. Previously, fall hogs were not included because of capital limitations. The profit maximizing plan for this capital level (Plan 23) includes 34 acres of CCOM and 119 acres of CSbCOM rotations fertilized at the third level, nine dairy cows, 24 litters of spring hogs, 13 litters of fall hogs, a supplementary laying flock of 100 hens, and the cash sale of 286 bushels of soybeans. Profits, with fixed costs subtracted, are $3,944. The greater amount of capital increases the degree of diversification of both the livestock and the cropping systems. Sufficient capital is now available to expand both the dairy and spring hog enterprise. However, neither enterprise can successfully compete for the total dairy barn space. Consequently, a combination of these two enterprises maximizes

profits. Dairy and spring hogs are included in the plan to the limit of the available building space before fall hogs and poultry are included to the limit of the remaining capital and October labor supply. Hence, the specified combination of livestock and crops is now a function of all limiting resources.

An alternative plan to Plan 23 with a different cropping system and some changes in livestock enterprises includes 115 acres of CCOM rotation and 38 acres of CSbCOM rotation fertilized at the third level, 10 dairy cows, 24 litters of spring hogs, 13 litters of fall hogs, and a supplementary laying flock of 100 hens. Net revenue for this alternative plan is $3,926 or only $18 less than optimum. These results indicate that, for this capital level, variation in both the cropping and livestock systems is feasible without materially affecting net income. Since several almost equally profitable plans exist for this capital-management level, the usefulness of these results for beginning farmers is increased as short run adjustments in enterprise combinations can be made. Flexibility of short run production opportunities enables tenants to adjust to risks and uncertainty without loss of much income.[1]

The optimum plan with capital not limiting differs very

---

[1]Heady, Earl O. Economics of agricultural production and resource use. Prentice-Hall, Inc., N.Y. 1952. pp. 500-534.

little from the previous plan. Plan 24 contains the same livestock enterprises but the cropping system is changed to include more corn and less soybeans. Since profits are only slightly increased, Plan 24 may be considered as just another alternative to Plan 23. The present plan includes a cropping system of 19 acres of CCSb, 97 acres of CCOM, and 37 acres of CSbCOM rotations, all fertilized at the third level. Profits for this plan, with fixed costs subtracted, are $3,982. The limiting resources for this plan are the same (except for capital) as for Plan 23. The similarity of the two plans is explained by the fact that only $15,811 of capital is used when capital is considered not limiting. The effect of adding $811 to the capital supply only increases the same livestock enterprises and rearranges the total acres planted to specific rotations. Most of the acres previously planted to a CSbCOM rotation are shifted to a CCOM rotation. Thus, the percent of the total acres planted to soybeans is decreased. Since profits are increased only $38 by making capital not limiting, it is doubtful if young farmers would find it profitable to borrow the additional capital ($811) required for this plan if risk and uncertainty are taken into account. In practice young farmers would probably choose Plan 23.

Optimum Plans with Above-Average Management for Feeder Cattle--Other Activities Average (Table 16)

Plans discussed in this section consider feeder cattle with above-average management and all other activities average (Table 16). Under these management conditions feeder cattle are able to compete for the limited resources when large amounts of capital are available. Feeder cattle were not included in previous plans (Plans 7 through 12, Table 13) with above-average livestock management because spring and fall hogs gave higher returns on the limited resources. Beginning operators with less than $15,000 can maximize profits by investing their capital in crops and spring hogs. Therefore Plans 25, 26, 27, and 28 are the same plans obtained previously (Plans 1, 2, 3, and 4 shown in Table 12) with average management for all activities.

When capital is increased to $15,000 with above-average management for feeder cattle (Plan 29), beginning operators can profitably invest their funds in feeder cattle. Of all the plans previously computed, this is the first plan to include feeder cattle. However, feeder cattle are still not successful in competing with spring hogs for capital. Consequently, feeder cattle are included in the present plan only after the size of the spring hog enterprise is determined by the building limitation. Since feeder cattle give higher

Table 16. Optimum plans with above-average management for feeder cattle (other activities average) on 160-acre Clarion-Webster, crop-share rented farm with different quantities of available capital

Plan	Capital level[a] ($)	Net return[b] ($)	Enterprises included in the farm plan	Crops	Acres	Limiting resources	Corn surplus or deficit (bu.)
25	3,000	911	147 acres $CCSb_3$	Corn	98	Capital	+2,584
				Soybeans	49		
26	5,000	1,598	135 acres $CCSb_3$	Corn	97	Capital	+1,257
			18 acres $CSbCOM_3$	Soybeans	48	Land	
			12 litters of spring hogs[c]	Oats	4		
				Meadow	4		
27	7,500	2,385	112 acres $CCSb_3$	Corn	91	Capital	- 679
			41 acres $CSbCOM_3$	Soybeans	46	Land	
			28 litters of spring hogs[c]	Oats	8		
				Meadow	8		
28	10,000	3,171	88 acres $CCSb_3$	Corn	85	Capital	-2,616
			65 acres $CSbCOM_3$	Soybeans	42	Land	
			43 litters of spring hogs[c]	Oats	13		
				Meadow	13		

[a]Capital above machinery investment of $11,159.

[b]Profits after fixed costs of $1,329 are subtracted.

[c]One litter includes a sow and 6.8 pigs weaned.

Table 16. (Continued)

Plan	Capital level ($)	Net return ($)	Enterprises included in the farm plan	Crops	Acres	Limiting resources	Corn surplus or deficit (bu.)
29	15,000	4,243	153 acres $CSbCOM_3$ 44 litters of spring hogs[c] 19 hens 16 choice calves (drylot) 19 choice calves (pasture)	Corn Soybeans Oats	62 31 30	Capital Land Hog housing July labor	-4,818
30	Capital not limiting (19,638)[e]		57 acres $CCOM_2$ 96 acres $CSbCOM_3$ 44 litters of spring hogs[c] 15 litters of fall hogs[d] 100 hens 28 choice calves (pasture)	Corn Soybeans Oats Meadow	67 20 33 33	Land Poultry and hog housing July labor November labor	-6,201

[c]One litter includes a sow and 6.8 pigs weaned.

[d]One litter includes a sow and 6.7 pigs weaned.

[e]Amount of capital that can be used with a given supply of limiting resources listed in Column 7.

returns on the remaining July labor and capital (not used by the spring hog and crop activities) than either dairy or fall hogs, feeder cattle can be profitably included. The forage needed by feeder cattle and hogs in this plan is supplied by the CSbCOM rotation. The farm plan with $15,000 (Plan 29) includes 153 acres of CSbCOM rotation fertilized at the third level, 44 spring litters, 16 choice calves fed in drylot, 19 choice calves full fed on pasture, a supplementary laying flock of 19 hens, and the cash sale of 367 bushels of soybeans. Profits, with fixed costs subtracted, are $4,243. The limiting resources for Plan 29 are capital, land, July labor, and building space. The result of increasing the capital supply to $15,000 is maintaining the same number of spring litters while adding a feeder cattle and a small poultry enterprise. Therefore, beginning farmers with less than $15,000 should not consider feeder cattle as an investment, if they wish to maximize profits.

The plan outlined above is the one which actually maximized profits for the resources considered. However, numerous other plans give returns almost as large and may be favored by some operators. Five alternative plans listed below include different livestock and cropping systems and none give less than $4,184 profits. These plans show that a wide range of flexibility in farm organization is possible when capital is adequate. The five alternative plans are:

Alternative Plan (1) includes 137 acres of CSbCOM and 16 acres of CCOM rotations, both rotations fertilized at the third level, 44 litters of spring hogs, 22 choice calves fed on pasture, 14 choice calves fed on drylot, and a supplementary laying flock of 24 hens. Profits, with fixed costs subtracted, are $4,242.

Alternative Plan (2) includes the same crop and livestock enterprises as the optimum plan except one fall litter replaces the 19 hens. Net revenue is $4,236.

Alternative Plan (3) includes the same livestock and crop enterprises as (1) except the 16 acres of CCOM rotation are fertilized at the fourth level. Net revenue is $4,229.

Alternative Plan (4) includes 40 acres of CCOM rotation fertilized at the second level, 10 acres of CCOM rotation fertilized at the fourth level, 103 acres of CSbCOM fertilized at the third level, 10 choice calves fed on drylot, 25 choice calves fed on pasture, 44 litters of spring hogs, and one litter of fall hogs. Net revenue is $4,198.

Alternative Plan (5) includes 57 acres of CCOM rotation fertilized at the second level, 9 acres of CCOM rotation fertilized at the fourth level, 87 acres of CSbCOM rotation fertilized at the third level, 44 litters of spring hogs, 26 choice calves fed on pasture, eight choice calves fed on drylot, and one litter of fall hogs. Net revenue for this plan is $4,184 or $59 less than for the optimum plan.

The optimum plan with capital not limiting and an above-average level of management for feeding cattle (Plan 30) differs considerably from Plan 29. The enterprise combination which maximizes profits for Plan 30 includes 96 acres of CSbCOM rotation fertilized at the third level, 57 acres of CCOM rotation fertilized at the second level, 44 litters of spring hogs, 28 choice calves fed on pasture, 15 litters of fall hogs, a supplementary laying flock of 100 hens, and the cash sale of 236 bushels of soybeans. Profits, with fixed costs subtracted, are $4,656. The limiting resources for this plan are land, July and November labor, and livestock housing. Total capital used is $19,638. In this plan the spring hog enterprise expands to the limit of the building space before fall hogs and feeder cattle are added. Since spring hogs do not exhaust the labor supply, fall hogs and feeder cattle are added to the limit of the remaining July and November labor supply. When capital is not limiting, addition of a fall hog enterprise and changing the cropping system to include more forage increases profits by $413. Part of the acres, originally planted to a CSbCOM rotation in Plan 29, is shifted to a CCOM rotation in Plan 30. This shift in rotations is necessary to produce the forage required for the feeder cattle in the latter plan.

An alternative to Plan 30, using $482 less capital and giving $150 less profits, includes 24 acres of CCSb, 57 acres

of CCOM, 72 acres of CSbCOM, all fertilized at the third level, 44 litters of spring hogs, 14 choice calves fed on drylot, 16 choice calves fed on pasture, and 14 litters of fall hogs. Profits for this plan are $4,506. Again it is true that when capital is not limiting several different combinations of rotations and livestock enterprises can be used without materially lowering net income. However, farmers probably would not choose this alternative plan since it includes three rotations. As pointed out earlier, farmers tend to keep away from a farm plan containing more than two rotations.

It should be noted that of all the previous capital-management levels considered, none gave so many alternative plans with almost equal profits as Plan 29. Flexibility in choice of enterprise combination is increased for all management situations at high capital levels. When young farmers have sufficient capital and, thus, several close alternative farm plans from which to choose, they are able to select one of several plans without any great sacrifice in profits. This flexibility of choice is desirable since no one farm plan is best for all farmers on the same soil type and a given quantity of resources. Each farmer must plan according to his own farm conditions, preferences for work load, resource limitations, and ability to shoulder risks. Farmers with a small amount of capital, not having as many equally profitable

alternative plans, are more limited in their choice of investment opportunities.

Optimum Plans with Above-Average Poultry Management--Other Activities Average (Table 17)

In foregoing plans, poultry was not included as an investment opportunity until capital was increased above $10,000. Since the enterprise considered is a small supplementary farm laying flock (poultry housing limits the flock size to 100 hens) and returns less to limited capital than other livestock, poultry cannot be profitably included at lower capital levels.[1] However, when beginning operators have above-average management proficiency in poultry and average ability in all other activities, poultry becomes a profitable investment (Table 17).

The optimum farm plan with above-average management for poultry and a capital level of $3,000 (Plan 31) includes only crops. As in all previous plans with $3,000, crop production and some fertilization of crops gives higher returns for small amounts of capital than do livestock.

---

[1]Here "profitably" refers to maximization of profit. While the poultry enterprise may return more than the cost, it is not a profitable enterprise to include in the farm plan if other enterprises will return more for the same resources.

Table 17. Optimum plans with above-average management for poultry (other activities average) on 160-acre Clarion-Webster, crop-share rented farm with different quantities of available capital

Plan	Capital level[a] ($)	Net return[b] ($)	Enterprises included in the farm plan	Crops	Acres	Limiting resources	Corn surplus or deficit (bu.)
31	3,000	911	147 acres $CCSb_3$	Corn	98	Capital	+2,589
				Soybeans	49		
32	5,000	1,609	141 acres $CCSb_3$	Corn	99	Capital	+1,755
			12 acres $CSbCOM_3$	Soybeans	50	Land	
			8 litters of spring hogs[c]	Oats	2	Poultry housing	
			100 hens	Meadow	2		
33	7,500	2,396	118 acres $CCSb_3$	Corn	93	Capital	- 352
			35 acres $CSbCOM_3$	Soybeans	46	Land	
			24 litters of spring hogs[c]	Oats	7	Hog and poultry housing	
			100 hens	Meadow	7		
34	10,000	3,183	94 acres $CCSb_3$	Corn	86	Capital	-2,282
			49 acres $CSbCOM_3$	Soybeans	43	Land	
			39 litters of spring hogs[c]	Oats	12	Hog and poultry housing	
			100 hens	Meadow	12		

[a]Capital above machinery investment of $11,159.

[b]Profits after fixed costs of $1,329 are subtracted.

[c]One litter includes a sow and 6.8 pigs weaned.

Table 17. (Continued)

Plan	Capital level ($)	Net return ($)	Enterprises included in the farm plan	Crops	Acres	Limiting resources	Corn surplus or deficit (bu.)
35	15,000	3,822	92 acres $CCSb_3$ 30 acres $CCOM_2$ 31 acres $CSbCOM_3$ 44 litters of spring hogs[c] 12 litters of fall hogs[d] 100 hens	Corn Soybeans Oats Meadow	88 37 14 14	Capital Land Hog, dairy and poultry housing October labor	-4,314
36	Capital not limiting (15,431)[e]	3,835	96 acres $CCSb_3$ 57 acres $CCOM_2$ 44 litters of spring hogs[c] 14 litters of fall hogs[d] 100 hens	Corn Soybeans Oats Meadow	93 32 14 14	Land Hog, poultry and dairy housing October labor	-4,398

[c]One litter includes a sow and 6.8 pigs weaned.

[d]One litter includes a sow and 6.7 pigs weaned.

[e]Amount of capital that can be used with a given supply of limiting resources listed in Column 7.

When capital is increased to $5,000, the profit maximizing plan with above-average poultry management (Plan 32) includes 141 acres of CCSb and 12 acres of CSbCOM rotations fertilized at the third level, eight litters of spring hogs, 100 hens, and the cash sale of 542 bushels of soybeans and 1,755 bushels of corn. Profits, with fixed costs subtracted, are $1,609. The limiting resources for this plan are capital, land, and poultry housing. This plan is essentially the same as the one obtained for Plan 2 (all activities with average management shown in Table 12) except a supplementary poultry enterprise has now been added. Profits are only slightly increased in the present plan by reducing the spring litters by four and adding 100 hens. The same crop rotations and fertilization levels are included in both plans, with only a slight change in the total acres in each rotation.

As capital is increased to $7,500, the spring hog enterprise is increased and the cropping plan is changed to include more meadow. Poultry housing limits the number of hens to 100 and this enterprise cannot be increased further. Plan 33 is very similar to Plan 3 (Table 12) obtained when all activities were considered at average management. This plan contains similar rotations but fewer spring litters and a poultry enterprise. Adding the poultry enterprise has very little effect on income ($11 more than Plan 3) and in practice this difference in profits would be ignored.

As capital is increased to $10,000 with above-average poultry management, Plan 34 includes similar crop and livestock enterprises as Plan 33. The greater amount of capital allows the spring hog enterprise to expand, leaving the poultry enterprise unchanged. The cropping system is changed to include more forage for the increased hog enterprise. Larger profits are due to the increased size of the hog enterprise. Similar recommendations regarding the type of enterprises can be given to beginning farmers with $7,500 and $10,000.

Inspection of Plan 34 (Table 17) and Plan 4 (Table 12) shows that changing the level of poultry management has very little effect on net income. With all activities at an average level of management (Table 12), poultry cannot successfully compete with spring hogs for limited capital, but changing the level of poultry management to above-average (Table 17) makes it profitable to include this enterprise. The difference in profits for Plans 34 and 4 is only $12, so in practice these two plans can be considered the same.

When capital is increased beyond $10,000, the optimum plans (35 and 36) are the same as Plans 5 and 6 (Table 12). Changing the level of poultry management has no effect on the most profitable combination of enterprises, but profits are increased slightly because of better management. Young farmers with more than $10,000 and preferring to invest their funds only in spring hogs would sacrifice very little income,

although specialization in hogs would not only mean some sacrifice in income, but would also increase income variability. Adding a poultry enterprise would be a means to diversify and spread risks and uncertainty of income. The choice of a particular plan, of course, would depend upon the individual preference.

Alternative Resource and Price Considerations

The above plans are optimum for tenants with different management skills in livestock production, and a given quantity of resources and specified price relationships. However, tenants faced with different price expectations and resource limitations may find quite different plans to be optimum. As mentioned previously, the beginning farmer, if he wishes to maximize profits, must plan according to his own farm conditions and resource limitations. Consequently, to consider a greater range of planning situations, the following plans consider different prices and resource limitations. In programming for these added situations, only one capital level has been used, $10,000. A single capital level is used to lessen the magnitude of the empirical calculations. However, use of the one level does suggest the changes which may need to be made in plans for particular price and resource situations.

Optimum plans with building limitation on hog enterprise (Table 18)

Not all tenants rent farms with sufficient building facilities to expand hog production to the point indicated in the foregoing plans. Previously, spring hogs competed with dairy cows for the dairy barn space and, since spring hogs gave larger net returns on limited capital than dairy cows, this enterprise was expanded to the limit of the capital supply. Limiting the size of the spring hog enterprise would have the effect of making more capital available to expand the diary, fall hog, or feeder cattle enterprises. For these reasons, optimum plans are computed with a building space restriction on the hog enterprise so investment opportunities can be outlined for tenants who are limited in the extent to which they are able to specialize in spring hogs. The optimum plans for the six levels of livestock management and $10,000 are summarized in Table 18.

All activities with average management. The profit maximizing plan for tenants with $10,000 and average management skills (Plan 37) is considerably different from Plan 4 (Table 12) when building restrictions are imposed on the plan. When the spring hog enterprise is limited to 13 litters, more capital becomes available for other livestock. Hence, Plan 37 includes a diversified crop and livestock program. In addi-

Table 18. Optimum plans for $10,000 capital and various management conditions with building restriction hog enterprise

Plan	Level of management	Net return[a] ($)	Enterprises included	Crop	Acres	Limiting resources	Corn surplus or deficit (bu.)
37	All activities average	2,181	66 acres $CCSb_3$ 67 acres $CCOM_3$ 20 acres $CSbCOM_3$ 13 spring & 8 fall litters of hogs[b] 6 dairy cows & 100 hens	Corn Soybeans Oats Meadow	85 26 21 21	Capital Land Hog & poultry housing	+ 700
38	All activities above-average	4,349	153 acres $CSbCOM_3$ 12 spring & 3 fall litters of hogs[c] 10 dairy cows & 100 hens	Corn Soybeans Oats Meadow	62 31 30 30	Capital Land Hog & poultry housing	+ 5
39	Hogs above-average (other activities average)	3,517	54 acres $CCSb_3$ 82 acres $CCOM_3$ 17 acres $CSbCOM_3$ 12 spring & 7 fall litters of hogs[c] 8 dairy cows & 100 hens	Corn Soybeans Oats Meadow	84 22 23 24	Capital Land Hog & poultry housing	+ 326

[a]Profits after fixed costs of $1,329 are subtracted.

[b]One litter includes a sow and 6.8 spring or 6.7 fall pigs weaned.

[c]One litter includes a sow and 7.3 spring or 7.2 fall pigs weaned.

Table 18. (Continued)

Plan	Level of management	Net return ($)	Enterprises included	Crop	Acres	Limiting resources	Corn surplus or deficit (bu.)
40	Dairy above-average (other activities average)	3,255	133 acres $CCOM_3$ 20 acres $CSbCOM_3$ 13 spring & 1 fall litters of hogs[b] 12 dairy cows & 100 hens	Corn Soybeans Oats Meadow	75 4 37 37	Capital Land Hog & poultry housing	+ 109
41	Feeder cattle above-average (other activities average)	2,812	14 acres $CCSb_3$ 139 acres $CSbCOM_3$ 13 litters of spring hogs[b] 36 choice calves (pasture)	Corn Soybeans Oats Meadow	64 33 28 28	Capital Land Hog housing	- 991
42	Poultry above-average (other activities average)	2,294	133 acres of $CCOM_3$ 20 acres $CSbCOM_3$ 13 spring & 4 fall litters of hogs[b] 12 dairy cows & 100 hens	Corn Soybeans Oats Meadow	75 4 37 37	Capital Land Poultry housing	+ 504

[b]One litter includes a sow and 6.8 spring or 6.7 fall pigs weaned.

tion to the 13 litters of spring hogs, the present plan includes eight litters of fall hogs, six dairy cows, and a supplementary laying flock of 100 hens. Profits for this plan, with fixed costs subtracted, are $2,181 or $990 less than for Plan 4 (Table 12). In Plan 37, spring and fall hogs are the first livestock activities to be included and expanded to the limit of the building space. Then dairy and poultry come into the plan to the limit of the remaining capital supply. The rotations selected are those which give the greatest profits with the above livestock so that, when the hog enterprise is limited to the hog house space outlined, it becomes necessary to use a more diversified crop and livestock program. Even though profits are reduced with diversification, Plan 37 would appeal to some operators who wish to spread risks and uncertainty of prices and incomes.

An alternative to Plan 37, giving $25 less profits and containing 5 percent more meadow, may be preferred by some farmers as it includes a larger dairy enterprise (nine cows), the same number of spring and fall litters, but no poultry. The greater amount of forage in this plan is necessary to provide the roughage for a larger dairy enterprise. A comparison of the alternative plan with the optimum plan shows that including a poultry enterprise decreases the dairy enterprise and the acres in CCOM. Thus, the question whether or not to add a poultry enterprise is now more important than

for previous plans when the hog enterprise was not limited to the hog house space. Again, it should be emphasized that there are several alternative combinations of livestock and crops that give almost equal profits. The choice of a plan would depend upon the individual and his farm conditions.

All activities with above-average management. The enterprises included in the farm plan for tenants with above-average management skills and $10,000 when the hog enterprise is limited to hog house space, are somewhat similar to those in Plan 37. Plan 38, with more dairy cows and a different rotation, includes 153 acres of CSbCOM rotation fertilized at the third level, 10 dairy cows, 12 litters of spring hogs, three litters of fall hogs, and a supplementary laying flock of 100 hens. Profits, $4,349, are almost twice as large as the previous plan. Therefore, tenants, renting farms with hog building restrictions as outlined above, can increase their income by improving their management skills in all livestock enterprises.

A comparison of Plan 38 with Plan 10 (Table 13) shows that profits are reduced by $1,533 when a limitation is placed on the size of the spring hog enterprise. This restriction has the effect of forcing into the plan other livestock enterprises giving lower returns on capital, thereby lowering profits. While the plan outlined above actually maxmizes profits for the resources considered, numerous other plans

give returns almost as large and may be preferred by some operators. One such plan, giving $40 less profit, includes the same livestock enterprises as Plan 38, but the cropping plan is changed to include only a CCOM rotation. In all alternative plans the spring hog enterprise expands to the limit of the hog house space before dairy, fall hogs, and poultry enterprises are included. Then these three enterprises expand to the limit of the remaining capital supply. Spring hogs are selected first because they give the greatest net returns for capital. Capital not used by the spring hog enterprise is most profitably used by fall hogs, dairy, and poultry. However, profits for all plans computed with the hog building restriction outlined here are lower than for Plan 10 (Table 13), which does not have this restriction for hogs. When the size of the most profitable enterprise (spring hogs) is limited, capital is made available for other livestock which return less profits.

Hogs with above-average management (other activities average). When management conditions are changed to include only hogs with above-average, the optimum plan (Plan 39) is only slightly different than Plans 37 and 38. The same livestock are included but in different proportions. The enterprises included in this plan differ considerably from those included in Plan 16 (Table 14) when the hog enterprise is limited by the hog building space. Plan 16 includes only

crops and spring hogs, whereas the present plan includes a diversified crop and livestock program. This plan includes 12 litters of spring hogs, seven litters of fall hogs, eight dairy cows, and 100 hens; the cropping system includes more forage for the dairy enterprise. As in Plans 37 and 38, when the hog enterprise is limited by building space, profits are reduced. Young farmers renting farms with less building space for hog production than indicated in Plan 16 (Table 14) are not able to specialize in spring hogs and must diversify to obtain the most profitable use of all resources. Hence, inadequate building facilities may serve to reduce income opportunities on some farms.

Dairy with above-average management (other activities average). When the hog enterprise is limited to 13 litters by building space and the management situation includes only dairy with above-average management, Plan 40 includes the same livestock enterprises, except for one fall litter, as Plan 22 (Table 15). More dairy cows are included in the present plan since the hog enterprise is limited. The cropping system is also changed to include more meadow for the larger dairy enterprise. The forage is supplied by a CCOM rotation, whereas in Plan 22 the forage is supplied by a CSbCOM rotation. Profits for the present plan are $3,255, $144 less than for Plan 22, which is much smaller than for Plans 37, 38, and 39, because similar livestock enterprises are selected, regardless of

the building restriction on the hog enterprise. Therefore, beginning farmers with above-average managerial ability only in dairying would need to make smaller enterprise adjustments to maintain income on farms with varying building facilities for hog production. The extent to which profits are reduced when the hog enterprise is limited by building facilities depends upon the level of livestock management considered.

Feeder cattle with above-average management (other activities average). When the management level is further changed to include only feeder cattle with above-average management and $10,000 (Plan 41), feeder cattle become a profitable investment alternative when the spring hog enterprise is restricted by a building limitation. Feeder cattle are not included in Plan 28 (Table 16) because spring hogs give higher returns on capital, but the present plan includes a feeder cattle enterprise in combination with spring hogs. As in Plan 28, the first livestock activity to come into the plan to the limit of the building space is spring hogs. Then the remaining capital is most profitably used by investing it in choice feeder calves to be fed out on pasture. The effect of limiting the size of the spring hog enterprise makes it profitable for tenants to invest in feeder cattle at lower capital levels than was indicated in plans computed without this building limitation for hogs (Table 16). However, profits ($2,812 or $359 less than Plan 28) are reduced when the spring

hog enterprise is limited to 13 litters. Since fewer litters are included in Plan 41, less grain would have to be purchased. Beginning farmers, not wanting to expand livestock production beyond the grain production of the farm, would probably prefer Plan 41 to Plan 28 because the soybean receipts in Plan 41 are almost sufficient to purchase the 991 bushels of corn required. Soybean receipts for Plan 28 are not nearly sufficient to purchase the 2,600 bushels of corn required.

Poultry with above-average management (other activities average). When the hog enterprise is limited by hog building space and the management level is changed to include only poultry with above-average management and $10,000, the optimum plan (Plan 42) is considerably different from Plan 34 (Table 17). In addition to the spring hog and poultry enterprises included in Plan 34, the plan now contains four litters of fall hogs and 12 dairy cows and the cropping system is changed to include more forage for the dairy enterprise. All the acres previously planted to a CCSb rotation and some of the acres planted to a CSbCOM rotation in Plan 34 are shifted to a CCOM rotation in the present plan. Beginning farmers must now diversify their livestock program to obtain the most profitable use of all resources. The reduction in income from diversification for this management situation is $889. Some operators may prefer Plan 42 to Plan 34 since diversification would reduce income variability. By adding a dairy

and fall hog enterprise, young farmers can diversify and spread risks and uncertainty of income.

Optimum plans with 1954 hog prices (Table 19)

Since adjusted long-run average prices were used in computing all previous plans, the question to be answered now is: What effect on income and farm organization would higher hog prices have? Consequently plans presented in this section are computed with 1954 hog prices (Table 19), which were generally higher in March and April but slightly lower in September and October than the long-run average prices used previously.

All activities with average management. The enterprises included in this optimum plan (Plan 43), with 1954 hog prices for tenants with average management ability and $10,000, differ considerably from the enterprises included in Plan 4 (Table 12) which are optimum for long-run average price relationships. The most profitable combination of crops and livestock in Plan 43 is fall hogs and a CCSb rotation; in Plan 4, spring hogs in combination with CCSb and CSbCOM rotations maximized profits. Since no forage is required by the fall hog enterprise in Plan 43, the total cultivated acres can be planted to corn and soybeans. Profits for the present plan are $3,637 or $466 more than Plan 4 (Table 12). Since larger

Table 19. Optimum plans for $10,000 capital, various management conditions and 1954 hog prices

Plan	Level of management	Net return[a] ($)	Enterprises included	Crop	Acres	Limiting resources	Corn surplus or deficit (bu.)
43	All activities average	3,637	153 acres of $CCSb_3$ 19 litters of fall hogs[b]	Corn Soybeans	102 51	Capital Land Hog housing	+ 169
44	All activities above-average	4,838	93 acres of $CCSb_3$ 60 acres of $CSbCOM_2$ 38 litters of spring hogs[c]	Corn Soybeans Oats Meadow	86 43 12 12	Capital Land Hog housing	-1,160
45	Hogs above-average (other activities average)	4,838	93 acres of $CCSb_3$ 60 acres of $CSbCOM_2$ 38 litters of spring hogs[c]	Corn Soybeans Oats Meadow	86 43 12 12	Capital Land Hog housing	-1,160
46	Dairy above-average (other activities average)	3,792	153 acres of $CSbCOM_3$ 10 litters of fall hogs[b] 10 dairy cows	Corn Soybeans Oats Meadow	62 31 30 30	Capital Land Hog housing	+ 304

[a]Profits after fixed costs of $1,329 are subtracted.

[b]One litter includes a sow and 6.7 pigs weaned.

[c]One litter includes a sow and 7.3 pigs weaned.

Table 19. (Continued)

Plan	Level of management	Net return ($)	Enterprises included	Crop	Acres	Limiting resources	Corn surplus or deficit (bu.)
47	Feeder cattle above-average (other activities average)	3,637	153 acres of $CCSb_3$ 19 litters of fall hogs[b]	Corn Soybeans	102 51	Capital Land Hog housing	+ 169
48	Poultry above-average (other) activities average)	3,637	153 acres of $CCSb_3$ 19 litters of fall hogs[b]	Corn Soybeans	102 51	Capital Land Hog housing	+ 169

[b]One litter includes a sow and 6.7 pigs weaned.

profits are due to higher prices for hogs marketed in April 1954, it is more profitable for tenants to concentrate on fall farrowings than spring farrowings. However, beginning farmers, in order ot maximize profits over time, should not invest their funds on the basis of one year's prices. The extent to which price changes in any one year alters the most profitable combination of enterprises should be considered, nevertheless, by a tenant in choosing a farm plan. A choice of a plan with only spring or fall hogs, or some combination of these two enterprises would depend upon the individual's price expectations and willingness to gamble on the uncertainty of these prices.

All activities with above-average management. The optimum plan (Plan 44), with 1954 hog prices for tenants with above-average management ability and $10,000, is the same as Plan 10 (Table 13) which is optimum for long-run average price relationships. Profits for Plan 44 are $1,044 less than for Plan 10. Spring hogs are included in the present plan instead of fall hogs, as in Plan 43, because the increased efficiency with above-average management offsets the tendency of prices to alter the most profitable farm organization. Therefore, the same farm organization is optimum for tenants who have $10,000 and above-average management ability for both 1954 hog prices and long-run prices. Recommendations to beginning farmers, concerning the choice of enter-

prises for the two price situations, depend upon the level of livestock management.

Hogs with above-average management (other activities average). When management conditions are changed to include above-average management only for hogs, the optimum plan (Plan 45) with 1954 hog prices is the same as Plan 16 (Table 14) with long-run average price relationships. As in Plan 44, the same organization is optimum for both price situations even though profits are less for both plans computed with 1954 hog prices. Higher hog prices do not alter the manner in which resources are allocated among enterprises for this management situation.

Dairy with above-average management (other activities average). The optimum plan, with 1954 hog prices when management conditions are changed to include only dairying with above-average management (Plan 46), is somewhat similar to Plan 22 (Table 15) which is optimum for long-run average price relationships. However, when 1954 hog prices are used, the combination of enterprises is changed to include a combination of fall hogs and dairy cows as shown in Plan 46, while in Plan 22 a combination of spring hogs and dairy cows maximized profits. The crop rotation is the same as in Plan 22 since the forage previously used by spring hogs is adequate for the increased dairy enterprise. Profits with 1954 hog prices are $393 more for Plan 46 than Plan 22 because of higher

prices for hogs marketed in April. Therefore, young farmers originally investing their funds in spring hogs and dairy cows would need only to shift to fall farrowings in order to maximize profits when prices deviate from the long-time average price relationships as in 1954.

Feeder cattle with above-average management (other activities average). When the management conditions are changed to include only feeder cattle with above-average management, the optimum plan (Plan 47) for 1954 hog prices differs considerably from Plan 28 (Table 16) which is optimum for long-run average prices. The present farm plan is identical to Plan 43 since feeder cattle cannot be included in the present plan because fall hogs give higher returns on capital. As in Plan 43, the spring hog enterprise is replaced with fall hogs in the optimum plan when 1954 hog prices are used instead of long-run average prices. Thus, consideration of feeder cattle as an investment opportunity does not change the most profitable combination of enterprises for the two price situations.

Poultry with above-average management (other activities average). The optimum plan (Plan 48) for 1954 hog prices and above-average poultry management is the same as Plan 47, in which fall hogs and cash crops (CCSb rotation) maximize profits with 1954 hog prices. The same combination of enterprises are optimum for Plans 43, 47, and 48 because similar

enterprises were included in the optimum plans with long-run average prices. Similar recommendations are appropriate for tenants with $10,000, regardless of the level of management used for poultry and feeder cattle.

Optimum plans with 1955 hog prices (Table 20)

Since the prices for hogs in 1955 were lower than long-run average prices used earlier, the question to be answered now is: What effect on income and farm organization would lower hog prices have? In all the plans computed so far, spring or fall hogs gave higher returns on limited capital than other livestock because of favorable hog prices. Consequently, the plans presented here are computed with 1955 hog prices (Table 20) to determine the extent to which beginning farmers need to make enterprise adjustments in years with low hog prices. With low hog prices young farmers may want to diversify to lessen income reduction. They may choose to make a sacrifice in long-run profits by diversification so long as risks and uncertainty are lessened.

All activities with average management. The optimum plan with 1955 hog prices for tenants with average managerial ability and $10,000 (Plan 49) differs considerably from Plan 4 (Table 12) which is optimum for long-run average prices. Instead of specialization in spring hogs, as in Plan 4, the

Table 20. Optimum plans for $10,000 capital, various management conditions and 1955 hog prices

Plan	Level of management	Net return[a] ($)	Enterprises included	Crop	Acres	Limiting resources	Corn surplus or deficit (bu.)
49	All activities average	1,407	153 acres $CCOM_3$ 8 litters of fall hogs[b] 14 dairy cows 100 hens	Corn Oats Meadow	77 38 38	Land Capital Livestock housing	+1,211
50	All activities above-average	3,403	153 acres $CSbCOM_3$ 19 litters of spring hogs[c] 9 dairy cows 100 hens	Corn Soybeans Oats Meadow	62 31 30 30	Land Capital Hog & poultry housing	- 313
51	Hogs above-average (other activities average)	3,114	99 acres $CCSb_3$ 54 acres $CSbCOM_3$ 38 litters of spring hogs[c]	Corn Soybeans Oats Meadow	88 43 11 11	Land Capital Hog housing	-1,056

[a]Profits after fixed costs of $1,329 are subtracted.

[b]One litter includes one sow and 6.7 pigs weaned.

[c]One litter includes one sow and 7.3 pigs weaned.

Table 20. (Continued)

Plan	Level of management	Net return ($)	Enterprises included	Crop	Acres	Limiting resources	Corn surplus or deficit (bu.)
52	Dairy above-average (other activities average)	2,750	153 acres $CCOM_3$ 6 litters of fall hogs[b] 13 dairy cows 100 hens	Corn Oats Meadow	77 38 38	Land Capital Poultry housing	+1,062
53	Feeder cattle above-average (other activities average)	2,594	153 acres $CSbCOM_3$ 9 choice calves (drylot) 42 choice calves (pasture)	Corn Soybeans Oats Meadow	62 31 30 30	Capital Land	- 327
54	Poultry above-average (other activities average)	1,535	153 acres $CCOM_3$ 8 litters of fall hogs[b] 14 dairy cows 100 hens	Corn Oats Meadow	77 38 38	Capital Land Livestock housing	+ 241

[b]One litter includes one sow and 6.7 pigs weaned.

farm plan now includes a diversified livestock program of fall hogs, poultry, and dairy cows. The cropping system is changed also to a CCOM rotation to supply the necessary forage for the 14 dairy cows. With 1955 hog prices, dairying is the most profitable livestock enterprise and therefore comes into the plan to the limit of the dairy building space. Then poultry and fall hogs are added to the limit of the remaining capital supply. Profits for this plan are $1,407 or 56 percent less than for Plan 4 (Table 12) with long-run average prices. In practice, farmers may not choose to make these indicated adjustments, especially if hog prices were expected to rise in the near future. However, if hog prices were expected to remain at the 1955 level for many years, the shift to dairying would probably be made. One way to guard against price uncertainty is to diversify the livestock program; such plans would not maximize profits in any one year but would tend to give a more stable income. Beginning farmers should plan according to their managerial abilities, resource limitations, and price expectations. Investing limited funds in a diversified farm plan is one way to maintain the flexibility needed to make the necessary adjustments to meet price uncertainty.[1]

All activities with above-average management. When the level of livestock management is changed to above-average for

---

[1]Heady, op. cit., pp. 500-534.

all activities, the effect of low hog prices on net income is not as great as with average management. Greater feeding efficiency tends to offset part of the effect of lower prices, but even with improved management, net income is reduced by 42 percent with 1955 hog prices. With above-average livestock management, young farmers need only to curtail their spring hog enterprise in Plan 10 (Table 13) and add a dairy and poultry enterprise in Plan 50. The farm plan with $10,000 and above-average management (Plan 50) includes 153 acres of CSbCOM rotation fertilized at the third level, nine dairy cows, 19 litters of spring hogs, and 100 hens. In this plan spring hogs are still profitable enough to compete for part of the limited funds. Having only spring litters and crops is only slightly less profitable than the specified combination of dairy and hogs. There are several combinations of these two livestock enterprises that can be considered as alternatives but each would give less than maximum profits. If tenants expect hog prices to rise in the near future, then some may prefer to sacrifice some profits and have only spring hogs. On the other hand, if some operators expected hog prices to remain low, a complete shift to all dairying might be made. In practice, where farmers have been in hog production before the price decline occurred, as in Plan 10 (Table 13), probably no enterprise adjustment would be made. This would be particularly true if tenants viewed the decline in hog prices

to be only temporary.

Hogs with above-average management (other activities average). The optimum plan with 1955 hog prices for tenants with above-average management only in swine production (Plan 51) is the same as Plan 16 (Table 14) which is optimum for long-run average prices. Therefore, tenants with $10,000 and above-average managerial ability in swine production would not need to make any adjustments in their farm organization when hog prices decline, except for a slight change in the cropping plan to include more acres of corn fertilized at the third level. Reduction in profits ($3,114 or $2,768 less than Plan 16) is quite large (47 percent) even though Plans 16 and 51 include practically the same enterprises. Hence, fluctuations in hog prices can materially affect profits and may lead some operators to choose dairy cows or some combination of spring hogs and dairy cows to guard against uncertainty of prices and income.

Dairy with above-average management (other activities average). When the management conditions are changed to include above-average management only in the dairy enterprise, the optimum plan (Plan 52) with 1955 hog prices differs considerably from Plan 22 (Table 15) which is optimum for long-run average prices. The spring hog enterprise included in Plan 22 is replaced with fall hogs in the present plan while the dairy and poultry enterprises are increased and the crop-

ping system is changed to a CCOM rotation to provide the necessary forage for the 13 dairy cows. Since the amount of forage produced limits the number of dairy cows, it is forage supply in this plan rather than dairy building space that limits this enterprise. Fall hogs and poultry are added then to the plan to the limit of the remaining capital. These results indicate that it would pay tenants to consider dairying rather than hogs as an investment opportunity if the prices for hogs in 1955 were expected to prevail in the future. Young farmers initially choosing a diversified farm plan (Plan 22, Table 15) will have less profits than Plans 4 and 10 (Tables 12 and 13, respectively) with high hog prices, but will have a smaller decrease in income (19 percent) under low hog prices. In making a choice between plans with a more steady income and plans with higher but more uncertain income, young farmers should keep in mind both short- and long-run effects of changing prices.

Feeder cattle with above-average management (other activities average). When management conditions are changed to include only feeder cattle with above-average management, the effect of low hog prices on income for tenants with $10,000 is not very large; the reduction in net income from Plan 28 (Table 16) with long-run average prices is only 18 percent. To maintain income at approximately the same level, tenants would have to reallocate their resources from spring hogs to

feeder cattle. Previously, the optimum plan (Plan 28) included spring hogs and crops. The present plan (Plan 53) includes 153 acres of CSbCOM rotation fertilized at the third level, nine choice calves fed on drylot, and 42 choice calves fed on pasture. In practice, a farmer would not divide his cattle into two feeding practices as indicated by this plan, but feed all the calves on pasture since profits would be reduced by only $20. This plan returns less profits because the additional forage required by the nine calves would be provided by a less profitable CCOM rotation. Under actual farm conditions, it would probably be more feasible to purchase additional hay so the alternative plan could be used. When 1955 hog prices are used, all plans yield less profits than Plan 28 (Table 16). In practice, beginning farmers may not choose to shift from spring hogs (Plan 28, Table 16) to feeder cattle (Plan 53) when hog prices decline because income variability would not be lessened. The choice of the two plans would depend upon the farmer's price expectations and preferences for certain types of livestock.

Poultry with above-average management (other activities average). The optimum farm plan with 1955 hog prices and above-average poultry management (Plan 54) is the same as Plan 49, which is optimum for average management in all activities; both can be considered as alternatives. The differ-

ence in net income of $128 for these two plans is due to the level of poultry management used. Hence, the enterprise adjustments to meet price uncertainty would be the same, regardless of the level of poultry management used.

Optimum plans with specified minimum size dairy and poultry enterprise (Table 21)

The plans which consider organization of the farm to meet uncertainty are presented in this section. To lessen risks, optimum plans now are computed in which small dairy and poultry enterprises are forced into the plans. It is known that dairy and poultry have less income variability; thus plans containing these two enterprises reduce uncertainty of income associated with price fluctuations.[1] Consequently, enterprises of 10 dairy cows and 200 hens have been forced into the plans with $10,000 for the six management levels. The hog enterprise considered in plans with uncertainty precautions is a two-litter hog system of equal spring and fall litters.

The main reason beginning farmers may prefer to diversify is to hedge against uncertainty of prices and income.

---

[1]Brown, William G. and Heady, Earl O. Economic instability and choices involving income and risk in livestock and poultry production. Iowa Agr. Exp. Sta. Res. Bul. 431. 1955. pp. 548-568.

Table 21. Optimum plans for $10,000 capital and various management conditions when each plan must contain at least 10 dairy cows, 200 hens and a two-litter hog system[a]

Plan	Level of management	Net return[b] ($)	Enterprises included[c]	Crop	Acres	Limiting resources	Corn surplus or deficit (bu.)
55	All activities average	2,087	11 acres $CSbCOM_3$ 100 acres $CCSb_3$ 10 dairy cows 313 hens 14 litters of hogs	Corn Soybeans Oats	86 35 3	Capital Land November labor	- 13
56	All activities above-average	4,337	9 acres $CSbCOM_2$ 93 acres $CCSb_3$ 10 dairy cows 200 hens 12 litters of hogs	Corn Soybeans Oats Meadow	87 33 2 31	Capital Land	+ 556
57	Hogs above-average (other activities average)	3,257	13 acres $CSbCOM_2$ 98 acres $CCSb_3$ 10 dairy cows 200 hens 16 litters of hogs	Corn Soybeans Oats	85 35 3	Capital Land Hog housing	+ 255

[a]No building or labor restriction is placed on the poultry enterprise for these plans.

[b]Profits after fixed costs of $1,329 are subtracted.

[c]The acres used to provide the grain and forage for the specified 10 dairy cows and 200 hens are included in Columns 5 and 6.

Table 21. (Continued)

Plan	Level of management	Net return ($)	Enterprises included	Crop	Acres	Limiting resources	Corn surplus or deficit (bu.)
58	Dairy above-average (other activities average)	3,399	44 acres $CSbCOM_3$ 58 acres $CCSb_3$ 14 dairy cows 306 hens 2 litters of hogs	Corn Soybeans Oats Meadow	78 28 9 38	Capital Land Dairy housing November labor	+ 943
59	Feeder cattle above-average (other activities average)	2,166	26 acres $CSbCOM_3$ 85 acres $CCSb_3$ 10 dairy cows 200 hens 14 litters of hogs 4 choice calves (pasture)	Corn Soybeans Oats Meadow	82 33 5 33	Capital Land November labor	- 185
60	Poultry above-average (other activities average)	2,602	111 acres $CCSb_3$ 10 dairy cows 663 hens	Corn Soybeans	89 37	Capital Land	+1,192

For farmers who borrow, a steady flow of income would reduce the need for credit and use of enterprises with less variable returns lessens the chances of being forced out of business in the event of two or three consecutive years of low prices. Too, some people prefer enterprises with less income variability to more profits since they are not willing to gamble. Hence, the above uncertainty precautions are incorporated in the plans, summarized in Table 21, so the effect on income and farm organization can be determined.

All activities with average management. The optimum plan with average management levels for all enterprises and $10,000 (Plan 55) with dairy and poultry forced into the plan, differs considerably from Plan 4 (Table 12) which does not have this uncertainty precaution imposed on the farm organization. Plan 55 includes 10 dairy cows and the necessary land to produce the feed for these cows (15 acres of corn and 27 acres of meadow), a laying flock of 313 hens, 14 litters of hogs, 100 acres of CCSb and 11 acres of CSbCOM rotations fertilized at the third level, and 494 bushels of soybeans sold for cash. In practice, the small number of acres of CSbCOM rotation would probably be ignored with the acres of corn, soybeans, and meadow being incorporated into a modified CCSb rotation. Adopting this plan would not materially reduce profits. Profits are less for Plan 55 than for Plan 4 (Table 12) because less profitable dairy and poultry enterprises are

forced into the plan. Since dairy and poultry enterprises in Plan 55 are predetermined in size, the rest of the farm plan is a function of the remaining capital and November labor supply. Hence, a certain amount of scarce resources are automatically allocated to the dairy and poultry enterprises and the remaining capital is most profitably used by increasing the specified laying flock of 200 hens and adding 14 litters of hogs. The result of specifying a certain type of a diversified plan which gives a steady and fairly certain income flow reduces profits by $1,084, or 34 percent. Operators desiring to diversify to hedge against uncertainty should be aware of the sacrifice in income that has to be made.

All activities with above-average management. The optimum plan (Plan 56) with above-average management for all livestock enterprises and $10,000 under uncertainty precautions is very similar to Plan 55 but differs considerably from Plan 10 (Table 13). In Plan 56 neither the dairy or poultry enterprise can be profitably expanded beyond the specified minimum. After the resource requirements for 10 dairy cows and 200 hens have been met, the two-litter hog enterprise and crops come into the plan to the limit of the remaining land and capital supply. The 51 acres of land required to support the dairy and poultry enterprises leave only 102 acres for other crop activities. The remaining land and capital causes the enterprises in Plan 56 to be most profitable under

the uncertainty precautions. The dairy and poultry enterprises are not increased in this plan because capital invested in hogs return higher profits. Profits for this plan are $4,337, or $1,545 less than for Plan 10 (Table 13) where all activities competed freely for the use of all resources. The reduction in profits of 26 percent is less than for Plan 55 with average management which indicates that the effects of diversification on income varies with the level of management considered. Beginning farmers, wanting to take uncertainty precautions by diversification, should increase their management skills to lessen the reduction of income.

Hogs with above-average management (other activities average). When the management conditions are changed to include above-average management only for hogs and $10,000 (Plan 57), the optimum plan is very similar to Plan 56, but differs considerably from Plan 16 (Table 14) when dairy and poultry enterprises are forced into the plan. Forcing less profitable dairy and poultry enterprises into the plan greatly reduces the size of the more profitable spring hog enterprise and, therefore, profits. After the capital requirements have been met for the minimum dairy and poultry enterprises, the remaining capital is most profitably used by investing in hogs. Profits for the present plan are $3,257, or $2,625 less than for Plan 16 (Table 14) which is optimum when all enterprises compete freely for all resources. Diversification for the

present management situation reduces profits more (45 percent) than when above-average management is used for all activities.

Dairy with above-average management (other activities average). When uncertainty precautions are considered, the farm plan with above-average management only in dairying and $10,000 (Plan 58) includes the same livestock as Plan 22 (Table 15). However, these enterprises now are combined in different proportions. Plan 58 includes 14 dairy cows (the capacity of the dairy barn), 300 hens, and two litters of hogs. In this plan November labor limits the expansion of the hog enterprise before the capital supply is exhausted. Therefore profits are maximized by increasing the dairy and poultry enterprises above their specified minimum number. The 51 acres of land required to support the specified 10 dairy cows and 200 hens leaves only 102 acres for other crop activities. This amount of remaining land, together with the remaining November labor, causes the combination of dairy and poultry to be most profitable when uncertainty precautions are imposed. However, profits for this plan, $3,399, are the same as for Plan 22 (Table 15). The effect of specifying a minimum dairy and poultry enterprise is to alter the combination of crops and livestock without affecting profits. The choice of these two plans would depend upon individual preferences for types of livestock.

Feeder cattle with above-average management (other

activities average). The optimum plan (Plan 59) under uncertainty precautions, when the management conditions are changed to include above-average for feeder cattle, differs considerably from Plan 28 (Table 16) where all enterprises competed freely for all resources. In addition to the specified 10 dairy cows and 200 hens, the present plan includes 14 litters of hogs and four choice calves fed on pasture. Forcing dairy and poultry enterprises into Plan 28 reduces the hog enterprise and lowers profits by $1,005, or 32 percent. This reduction in income is similar to Plan 55 because the same farm organizations were optimum for tenants without uncertainty precautions (Plan 4 in Table 12 and Plan 28 in Table 16). Consideration of feeder cattle as an investment opportunity when uncertainty precautions are taken does not materially alter the most profitable combination of enterprises. Only a few feeder cattle can be profitably included since hogs give higher returns on capital. Also, variability of income would be increased if more feeder cattle were included in the plan.[1] Consequently, tenants with $10,000 and average managerial ability in all activities except feeder cattle should not consider feeder cattle as an investment, if they wish to reduce uncertainty associated with price fluctuations. In practice, Plan 55 can be considered as a feasible alternative

---

[1]Brown and Heady, op. cit., pp. 548-568.

to the present plan since similar enterprise adjustments are made when uncertainty precautions are taken.

Poultry with above-average management (other activities average). The optimum plan with above-average poultry management and $10,000 (Plan 60) differs considerably from the previous plans when uncertainty precautions are taken. With no building and labor limitations on the poultry enterprise, poultry becomes the most profitable livestock enterprise under uncertainty precautions. After the resource requirements for the specified 10 dairy cows and 200 hens have been met, the most profitable allocation of the remaining capital and land is to expand the poultry enterprise and to plant a CCSb rotation. Profits for Plan 60, with fixed costs subtracted, are $2,602 or only $581 less than Plan 34 (Table 17) where all activities competed freely for the use of all the resources. Taking uncertainty precautions reduces income under this management situation by 18 percent. The implication of removing the building and labor limitations on the poultry enterprise is clearly shown by the farm organization in Plan 60. Had these limitations not been removed (under the uncertainty precautions imposed) the resulting plan would have been very similar to Plan 55 with average management for all activities. Hence, beginning operators with above-average poultry management, wanting to diversify to meet uncertainty, should expand the poultry enterprise when sufficient labor and

housing are available. In practice, young farmers may not be able to adopt the present plan since rented farms typically do not have sufficient poultry housing facilities for 663 hens. Therefore this plan may have a more limited application than Plan 55.

Optimum plans with fixed feed supply (Table 22)

Not all tenants rent farms with leasing arrangements which permit them to choose a rotation and to purchase grain and expand livestock production beyond the feed produced on the farm. Farm plans with feed supply limited to a rotation specified by the landlord may be quite different from the plans previously computed with rotations and feed supply variable. When the rotation is specified by the landlord and livestock production limited to the feed produced, livestock production must be adjusted to the fixed feed supply. Hence, the livestock enterprises included in the optimum plan with a fixed feed supply are those that give the highest returns on limited capital, labor, building space, and feed supply. The profit maximizing plans with a fixed feed supply and specified rotation for the six levels of livestock management are summarized in Table 22.

The cropping system used for computing plans in this

Table 22. Optimum plans with rotations and feed supply fixed with $10,000 of capital[a]

Plan	Management level	Net return[b]	Livestock included	Crops[c]	Acres	Limiting resources	Capital used[d]
61	All activities average	$1,667	16 spring litters 5 dairy cows	Corn Soybeans Oats Meadow	73 26 30 24	Corn July labor Poultry housing	$6,801
62	All activites above-average	$3,789	22 spring litters 3 dairy cows 100 hens	Corn Soybeans Oats Meadow	73 26 30 24	Corn July labor Poultry housing	$7,988
63	Hogs above-average (other activities average)	$3,427	23 spring litters 3 dairy cows	Corn Soybeans Oats Meadow	73 26 30 24	Corn July labor	$7,669

[a]Capital above machinery investment of $11,159.

[b]Profits after fixed cost of $1,329 are subtracted.

[c]Five year cropping plan for modal farm selected for this study.

[d]Actual amount of capital that can be used when feed supply is fixed.

Table 22. (Continued)

Plan	Management level	Net return	Livestock included	Crops	Acres	Limiting resources	Capital used
64	Dairy above-average (other activities average)	$2,247	16 spring litters 5 dairy calves 100 hens	Corn Soybeans Oats Meadow	73 26 30 24	Corn July labor Poultry housing	$7,035
65	Feeder cattle above-average (other activities average)	$2,125	20 med. yearlings, drylot fed 28 choice calves, pasture fed 100 hens	Corn Soybeans Oats Meadow	73 26 30 24	Capital Corn July labor Poultry housing Forage	$10,000
66	Poultry above-average (other activities average)	$1,781	16 spring litters 5 dairy cows 100 hens	Corn Soybeans Oats Meadow	73 26 30 24	Corn July labor Poultry housing	$6,818

section is the one found on the typical farm selected as a basis for analysis (Table 1).[1] The feed produced from this cropping system of 73 acres of corn, 26 acres of soybeans, 30 acres of oats, and 24 acres of meadow is treated as a fixed resource to be allocated to the basic livestock enterprises considered in this study. Total crop production from the specified cropping system includes 2,320 bushels of grain, 247 bushels of soybeans, and 60 tons of hay.

All activities with average management. The optimum plan for $10,000, average management for all activities, and a feed limitation (Plan 61) is quite different from Plan 4 (Table 12). When the feed supply is fixed, a combination of dairy, hogs, and poultry maximizes profits. Since additional grain cannot be purchased (a total of 2,616 bushels are purchased in Plan 4), the spring hog enterprise cannot be expanded beyond 19 litters. Consequently, the supply of corn, together with July labor not used by crops, causes a combination of dairy, poultry, and spring hogs to be most profitable. The farm plan (Plan 61) includes 16 litters of spring hogs, five dairy cows, and 100 hens. In this plan, capital is not limiting at $6,801 because corn and July labor are exhausted. The extent to which capital can be employed, therefore, is greatly

---

[1]The average number of acres planted to the various crops for the past five years (1950-55) on the modal farm is used as being representative of the crop-share leasing system.

limited when livestock production is restricted to home produced feeds. Profits are larger in Plan 4 (Table 12) because the most profitable spring hog enterprise is not limited by a fixed feed supply. Hence, income opportunities for beginning farmers can be increased if rotations and feed supply are not fixed. Allowing tenants to choose rotations and to expand livestock production beyond the feed produced on the farm, also would increase the landlord's income by nearly $500. Removing the restrictions on feed and rotations, therefore, would increase incomes for both parties.

All activities with above-average management. With above-average management for all activities and $10,000, the optimum plan (Plan 62) with a fixed feed supply is very similar to Plan 61 but differs considerably from Plan 10 (Table 13). Plan 62 includes a diversified farm plan of dairy, poultry, and spring hogs, while Plan 10 includes only spring hogs. In the present plan, spring hogs are still the most profitable livestock enterprise and is more efficient in the use of grain than dairy or poultry. Therefore spring hogs come into the plan to the limit of the grain supply before dairy cows and poultry are included to the limit of the remaining supply of July labor not used by the hog and crop enterprises. However, as dairy and poultry are added to the plan, the spring hog activity is decreased and some of the feed supply is reallocated to dairy and poultry enterprises. The farm plan (Plan

62) includes 22 litters of spring hogs, three dairy cows, and 100 hens. Obviously, there are several combinations of spring hogs and dairy cows (other than the optimum) that can be considered. Each alternative livestock combination would give less than maximum profits, although in some cases profits are only slightly less and may well be preferred by some operators. However, profits for all plans with a fixed feed supply are less than Plan 10 (Table 13) which does not have this limitation on the feed supply. The reduction in profits is less for tenants with above-average management than with average management but, as in Plan 61, profits for both the landlord and tenant are reduced when the feed supply is fixed. Therefore, removal of limitations on the feed supply imposed by the landlord is one way of improving welfare (income) of both tenant and landlord, regardless of the level of livestock management considered.

Hogs with above-average management (other activities average). The enterprises included in the optimum plan with above-average swine management and a fixed feed supply (Plan 63) are the same, except for poultry, as in Plan 62. However, Plan 63 does differ considerably from Plan 16 (Table 14) when a feed limitation is imposed. Previously in Plan 16, spring hogs in combination with crops maximized profits while a combination of three dairy cows and 23 litters of spring hogs is now optimum with a fixed feed supply. The supply of grain,

together with the remaining July labor not used by the specified rotation, causes the specified combination of dairy and hogs to be most profitable. As in Plan 62, however, profits are reduced when livestock production is limited to home produced feeds. Since the same enterprises, except for poultry, are included in Plans 62 and 63, similar recommendations would be appropriate for tenants with $10,000, regardless of the level of dairy management.

Dairy with above-average management (other activities average). The enterprises included in the optimum plan with above-average dairy management and a fixed feed supply (Plan 64) are the same as in Plan 22 (Table 15) which does not have this feed limitation. However, the present plan contains fewer litters of spring hogs and fewer dairy cows, because of feed limitations, but a larger poultry enterprise and, consequently, profits are reduced by 34 percent. This reduction in income is less than for Plan 61 with average management for all activities. The reduction in income is 11 percent more for Plan 61 even though Plans 61 and 64 are identical. Hence, the effect on income of limiting livestock production to the feed produced varies with the level of livestock management used. Beginning farmers must plan, if they wish to maximize profits, according to their own managerial abilities and resource limitations. Planning according to a given set of prices and resource supplies and ignoring manage-

ment may be misleading.

Feeder cattle with above-average management (other activities average). The optimum plan with above-average management in feeder cattle and a fixed feed supply (Plan 65) differs considerably from Plan 28 (Table 16) which does not have this feed limitation. In Plan 28 specialization in spring hogs maximized profits; in Plan 65, a combination of feeder cattle and poultry give the highest returns on the fixed resources. The fixed feed supply, together with the remaining July labor not used by the specified rotation, causes the combination of 100 hens, 20 medium yearlings, and 28 choice calves fed on pasture to be most profitable. As with previous plans with a fixed feed supply, profits for the present plan are reduced when a feed lim tation is imposed. Again, it should be emphasized that income opportunities can be increased for both tenants and landlords if livestock production is not limited to home produced feeds. Since profits are reduced for tenants with a feed restriction, the length of time required to get established would also be greater. Hence, the success of an extension program designed to help beginning farmers get established on some farms would depend upon the education of both landlords and tenants.

Poultry with above-average management (other activities average). The optimum plan with above-average poultry management and a fixed feed supply (Plan 66) is identical to Plan 61

but differs considerably from Plan 34 (Table 17) which does not have a feed limitation. In addition to the spring hog and poultry enterprises included in Plan 34, the present plan includes a dairy enterprise. As in Plan 61, the fixed supply of grain, together with the remaining July labor not used by crops, causes the combination of 16 litters of spring hogs, 100 hens, and five dairy cows to be most profitable. Likewise, profits are less than Plan 34 (Table 17) since the supply of home produced grain limits the size of the spring hog enterprise. Hence, income opportunities for beginning farmers are much greater on farms without a feed limitation on livestock production.

All the plans considered in this section have the same limiting resources, except Plan 62, in which July labor is not limiting. The main difference in any of these plans compared with the plans with similar capital levels, but with no limitation on the feed supply (Tables 12 through 17), is the level of profits and livestock included. In the plans computed earlier with no feed limitation, the predominant livestock enterprise was spring hogs and therefore less forage is produced in these plans. When the landlord specifies the crops to be grown and that livestock production cannot exceed the feed produced, the farm plans include only those livestock enterprises that utilize the grain and forage most profitably. The plans in this section illustrate the need for beginning

farmers to choose plans that best fit individual farm conditions if profits are to be maximized.

Optimum plans with above-average crop management (Table 23)

In all previous plans the level of crop management was considered as average. However, tenants with above-average skills in crop production may find quite different plans to be optimum. To maximize profits, tenants must plan according to their individual management abilities and resource limitations. Consequently, to consider a greater range of planning situations, the plans in Table 23 consider crop management to be above-average. These plans indicate how profits and farm organization change when improved crop practices are used for the six levels of livestock management.

All livestock activities with average management. The enterprises included in the optimum plan with above-average management only for crops (Plan 67) are the same as in Plan 4 (Table 12) with average crop management. Hence, the level of crop management used does not affect the most profitable combination of enterprises. Profits for the present plan are $226 more than for Plan 4, therefore these results indicate that young farmers can improve their incomes by using improved crop practices. This opportunity to increase income is of

Table 23. Optimum plans for $10,000 capital and various livestock management conditions with above-average crop management

Plan	Level of livestock management	Net return[a] ($)	Enterprises included	Crop	Acres	Limiting resources	Corn surplus or deficit (bu.)
67	All activities average	3,397	88 acres CCSb3 65 acres CSbCOM3 43 litters of spring hogs[b]	Corn Soybeans Oats Meadow	85 42 13 13	Capital Land Hog housing	-2,421
68	All activities above-average	6,088	99 acres CCSb3 54 acres CSbCOM3 37 litters of spring hogs[c]	Corn Soybeans Oats Meadow	88 43 11 11	Capital Land Hog housing	- 862
69	Hogs above-average (other activities average)	6,088	99 acres CCSb3 54 acres CSbCOM3 37 litters of spring hogs[c]	Corn Soybeans Oats Meadow	88 43 11 11	Capital Land Hog housing	- 862

[a]Profits above fixed costs of $1,329.

[b]One litter includes one sow and 6.8 pigs weaned.

[c]One litter includes one sow and 7.3 pigs weaned.

Table 23. (Continued)

Plan	Level of livestock management	Net return ($)	Enterprises included	Crop	Acres	Limiting resources	Corn surplus or deficit (bu.)
70	Dairy above-average (other activities average)	3,589	153 acres $CSbCOM_4$ 25 litters of spring hogs[b] 9 dairy cows 100 hens	Corn Soybeans Oats Meadow	62 31 30 30	Capital Land Hog and poultry housing	-1,168
71	Feeder cattle above-average (other activities average)	3,397	88 acres $CCSb_3$ 65 acres $CSbCOM_3$ 43 litters of spring hogs[b]	Corn Soybeans Oats Meadow	85 42 13 13	Capital Land Hog housing	-2,421
72	Poultry above-average (other activities average)	3,410	94 acres $CCSb_3$ 59 acres $CSbCOM_3$ 39 litters of spring hogs[b] 100 hens	Corn Soybeans Oats Meadow	86 43 12 12	Capital Land Hog and poultry housing	-2,085

[b]One litter includes one sow and 6.8 pigs weaned.

particular importance to beginning farmers with very small amounts of capital since investment in crops and some fertilization of crops give higher returns than livestock.

All activities with above-average management. When both crops and livestock are considered with above-average management, the optimum plan with $10,000 (Plan 68) is the same as Plan 10 (Table 13) with average crop management. As in Plan 67, profits are increased when improved crop management is used. Therefore, income can be increased with improved crop management, regardless of the level of livestock management used.

Hogs with above-average management (other livestock activities average). When above-average management is used for only crops and hogs, the optimum plan with $10,000 (Plan 69) is the same plan as Plan 16 (Table 14) with average crop management. As in Plan 68 (which is identical to the present plan), profits are increased when improved crop practices are used. Therefore similar recommendations are appropriate for tenants with above-average swine management, regardless of the level of crop management used.

Dairy with above-average management (other livestock activities average). The optimum plan (Plan 70) with above-average management for crop and dairy activities, differs very little from Plan 22 (Table 15) with average crop management. The present plan includes the same livestock enterprises as

Plan 22, but in different combinations, and the cropping system also is the same except the CSbCOM rotation is now fertilized at the fourth level. Thus, for the first time, it is profitable to use the highest rate of fertilization for the whole farm. The increase in profits for this plan, $170 more than for Plan 22 (Table 15) with average crop management, is due to improved crop practices which give higher grain yields for the same capital expenditures. Since less grain has to be purchased to meet the feed requirements of livestock production with above-average crop management, net revenue is increased. Hence, improving the efficiency of crop production offers beginning farmers an additional opportunity to increase incomes on crop-share rented farms.

Feeder cattle with above-average management (other livestock activities average). When feeder cattle and crops are considered with above-average management, the optimum plan with $10,000 (Plan 71) is the same as Plan 28 (Table 16) with average crop management. However, profits for Plan 71 are $3,397 or $226 more than Plan 28 because of higher crop yields under improved crop management. Plan 71 is identical to Plan 67 because feeder cattle cannot be profitably included in the present plan. Regardless of the level of management used for crops and feeder cattle, similar recommendations are appropriate for beginning farmers with $10,000 and average management ability in other activities.

Poultry with above-average management (other livestock activities average). The enterprises included in the optimum plan (Plan 72) with above-average crop and poultry management are the same as in Plan 34 (Table 17) with average crop management. Changing the level of crop management does not affect the most profitable combination of enterprises; only profits are increased. Therefore, beginning farmers need not consider crop management in their choice of farm organization. Even though incomes can be increased through improved crop practices some young farmers may prefer Plan 34 to the present plan because of the extra effort and time required to insure timeliness of crop operations. The choice of plans would depend, therefore, on the individual and his preferences for crops or livestock.

APPLICATION OF LINEAR PROGRAMMING TO EXTENSION: POSSIBILITIES AND LIMITATIONS

Use of the linear programming technique in farm management research or for individual farm planning has promise for extensive use in the future. Currently, its major use is in farm management research of modal farm situations to provide background information as bases for extension recommendations. Because the use of this technique has been limited thus far to farm management research does not mean that this method of analysis could not and will not be used to plan individual farms on a broad scale. Rather, the limited use has been the result of inadequate funds, computing facilities, and trained personnel to carry out an extensive farm planning program. Consequently, linear programming is used primarily in research of modal farm situations, the results of which have a wide application in the homogenous area analyzed.

Linear programming is well adapted to the analysis of modal farm situations. In relatively homogeneous farming areas, as in central Iowa, the results obtained are applicable to a large number of farms. County extension personnel, by use of partial budgeting, can make the results obtained for modal farm situations applicable to farms with similar resource limitations, soil types, and other farm conditions. The use of linear programming in farm management research to

provide benchmarks for use in making extension recommendations should serve an important service to the farmer. Linear programming closely approximates the complex decision-making process of the farm family by bringing together the whole complex of prices, resource limitations, the relevant technical data and relationships about the various enterprises and simultaneously solving for optimum combination of enterprises. This method of analysis closely approaches reality by focusing attention on the whole decision-making process.

Use of linear programming in an extensive farm planning program for individual farms would be very important to a state extension program and would make a major contribution in supplying relevant information needed for individual decision-making. Such a program would offer a way of reaching hundreds of farmers directly with information based on empirical research. In a program of this type, the county extension personnel would play a major role, both in obtaining the relevant basic data and farm characteristics and in implementing the adoption of the resulting plans. A service of this nature given by the college and the extension service would be an effective way of disseminating research information and at the same time achieving the extension service objective of education.

At present, the lack of adequate computing facilities and limited funds appear to make use of linear programming in

analysis of modal situations more profitable than for individual farm planning. Providing background information for extension personnel to help direct recommendations to farmers makes possible immediate use of this method of analysis. However, as this technique becomes perfected and more funds and computing facilities (electronic computers) are made available, planning individual farms should be practical. Without adequate facilities, planning on a farm basis would not be feasible in terms of maximizing returns to the limited funds and personnel.

The validity of the results obtained by linear programming are dependent on the reliability of the basic data used. The importance of getting reliable input-output coefficients is clearly emphasized by this method of analysis. It must be remembered that the linear programming technique is essentially an integrating tool of farm planning. It does not provide the basic input-output data or the resource characteristics of the farm; rather, it utilizes these data. Hence, use of this technique in farm planning poses a challenge to future technical research to provide reliable basic input-output data. Likewise, a challenge is also made to those who would use this technique in farm management research or actual farm planning. Adequately formulating the problem to be analyzed is of major importance. As with the basic input-output coefficients, the prices used and the manner in which

the problem is formulated affects the validity of the final results.

Use of the linear programming technique as an educational tool in farm and home planning appears even less practical in view of the present state of economic knowledge of county extension personnel. This does not imply that all who use the results of linear programming should be economists; rather, a knowledge of the assumptions and limitations involved in linear programming should be sufficient. An understanding of the economic principle of opportunity costs is required before the results obtained by the linear programming technique can be interpreted and applied by county extension personnel. Even on an individual farm planning basis, an educational program carried out by county personnel would greatly implement the adoption and application of plans obtained by linear programming. What is needed, then, is some preparatory training of extension personnel before any real success is to be expected from the use of linear programming on a broad individual farm basis or in providing background information from typical farm situations.

SUMMARY

The specific objective of this study was to determine farm plans which best fit the resources of beginning farmers who are tenants on crop-share rented farms in central Iowa. To accomplish this objective optimum plans were computed for various capital and management situations by use of the linear programming technique. This procedure was followed since quite different recommendations appeared appropriate for tenants with different managerial abilities and different resource supplies. In computing optimum plans, consideration was given to the nature of all limiting resources including land, labor, feed, buildings, capital, and managerial ability.

The farm situation selected for analysis is located in central Iowa and was judged typical of crop share-rented farms in this area. The predominant soil type on this farm is Clarion-Webster. The farm selected was judged to be typical in terms of leasing conditions, farm size, and in type and quantities of building and machinery facilities available. The labor supply for competitive enterprises was supplied by the operator and his family. It was assumed that livestock production could not exceed the forage production of the farm and hay had a zero market price. Thus, any surplus hay not consumed would go unused. However, surplus grain could be sold and any deficit grain could be purchased.

The basic enterprises or investment opportunities considered in this study were: three crop rotations, each with four levels of fertilization; feeder cattle fed on pasture; two types of feeder cattle fed on drylot; a dairy enterprise; a poultry enterprise; a fall hog enterprise; and a spring hog enterprise with pigs on pasture. While numerous crop and livestock enterprises are available to crop-share tenants in central Iowa, only those that were typical of the area were considered. All enterprises competed freely for the use of the resources, except poultry which competed only for capital and was supplementary in the use of labor. Long-run price relationships (adjusted to 1954 levels) were used in this study except for some plans computed with 1954 and 1955 hog prices. Various resource restrictions were imposed on the above enterprises so the effects of these restrictions could be observed. The resulting solutions gave a range of alternative farm plans that are applicable to a variety of farm conditions.

With beginning farmers capital is typically the most limiting resource and the amount possessed varies with individuals. Also, not all farmers possess equal managerial skills in livestock production. Therefore, profit maximizing plans were computed for each of several different combinations of capital and livestock management situations for a given supply of land, labor, and building space. The six different

capital levels considered were: $3,000, $5,000, $7,500, $10,000, $15,000, and capital not limiting. In conjunction with the six capital levels, six combinations of livestock management were considered. The resulting plans were those that maximize profits for the tenant. Optimum plans for a landlord or owner-operator may be different from those presented. However, linear programming methods also would allow selection of the most profitable plan under these circumstances.

Where all enterprises competed freely for the use of resources, the effect of management on enterprise combinations depended upon capital availability. When capital was limited to $3,000, managerial ability in livestock production had no effect on the selection of enterprises and the most profitable farm plan included a corn-corn-soybean rotation fertilized at the third level with the grain sold for cash. Use of all funds for crop production and some fertilization gave greater profits when capital was very limited. In the ordering of investment, some fertilization of crops was always more profitable than investment in livestock. Of course, as capital was increased, funds could be profitably invested in livestock. Livestock did not become profitable until $5,000 of capital was available. Optimum plans then included spring hogs with the above rotation when management was at average levels for all enterprises. As capital was increased and the

most profitable plan included livestock, the above rotation was partially replaced by a corn-soybean-corn-oats-meadow rotation to provide forage. As capital was increased beyond $5,000, the spring hog enterprise expanded until hog building space became limitational. This situation held true for all management situations, except when the tenant was above-average in dairying, but average in raising hogs. In the latter case, both dairy and spring hogs were expanded to the limit of available building space. Fall hogs, feeder cattle and poultry, in general, became profitable investment opportunities only when capital was increased beyond $10,000. With this amount of capital, the enterprises included in the optimum plans were related to the nature of all limiting resources and the level of livestock management. Dairying was included in the plan only when management was above-average for this enterprise but was at average levels for all other enterprises. Spring and fall hogs and poultry were included in all optimum plans at high capital levels, regardless of the level of livestock management considered. Flexibility of enterprise combinations was increased in all plans at high levels of available capital. However, the level of profits for plans at high capital levels was directly related to the level of livestock management. As capital and livestock were increased, plans generally included more forage in the rotation. However, the maximum amount of forage profitable in

any plan was 25 percent of the total crop acres.

To consider a wider range of planning situations, optimum plans also were computed which involve diversified livestock programs resulting from reduction in the most profitable enterprise (spring hogs) either by a building limitation or by risk aversion. When the size of the hog enterprise was limited to 13 litters by building space, the optimum combination of enterprises varied with the level of livestock management. Limiting the most profitable livestock enterprise (spring hogs) caused less profitable livestock enterprises to be included in the farm plans for all management situations. Adding high forage consuming livestock (dairy or feeder cattle) to the farm plan resulted in a higher proportion of the land being planted to meadow. Thus, placing a limitation of the size of the spring hog enterprise reduced profits. Profits were reduced for one situation by as much as 39 percent; for other situations the reduction in profits was less. Profits were only slightly reduced for the situation with above-average management for the dairy enterprise and all other enterprises with average management. Diversification reduced profits more with average management for all activities than with above-average management for all activities. Similar reductions in net incomes were obtained for all management situations where all plans contained at least 10 dairy cows, 200 hens, and a two-litter hog system. Obviously, diversification to meet

risks lowers farm profits, however, many beginning farmers with small amounts of capital or low equity will prefer less profit, as long as it lowers risks.

Plans were computed also for 1954 and 1955 hog prices because variation in product prices influences the most profitable combination of crops and livestock. These plans indicated that when hog prices fall in relation to other livestock prices, feeder cattle and dairying become relatively more profitable than spring hogs when management was average. With above-average management, the improved feeding efficiency tended to offset part of the effects of lower hog prices. Consequently, the need for diversification of livestock enterprises to guard against price uncertainty was greater for beginning farmers with average management. Hence, improvement of managerial ability should increase income and also enhance the ability of young farmers to withstand periods of unfavorable prices.

Some plans were computed also for above-average crop management since improved cropping efficiency may affect the kind and amount of livestock selected. Plans obtained with above-average crop management instead of average management indicated that the selection of the most profitable combination of crops and livestock was not affected by the level of crop management. Only profits were increased. Hence, crop management does not alter the basic recommendations that are appropriate

for beginning farmers.

In general, when capital is available in very limited quantities the most profitable investment opportunity for beginning farmers was crop production and fertilization of crops. Investing in livestock production was profitable only after sufficient capital was available to meet the capital requirements of crop production. Therefore, beginning farmers with small amounts of capital should invest their funds in improving crop yields by fertilization before investing in livestock, if they wish to maximize profits.

The results of this study indicated that optimum farm plans for beginning farmers were related to capital availability, managerial ability, and other resource supplies. Hence, a universal recommendation would not be appropriate for all farmers on the same farm and soil type. Supplies of resources and managerial ability differ among farms and individuals, thereby causing different organization of enterprises to be most profitable. In several capital and management situations, especially at high capital levels, several almost equally profitable plans were obtained. Thus, a wide range of choice of alternative farm plans was possible with sufficient capital. When farmers have a number of alternative plans from which to choose, the degree of flexibility of farm organization is increased, thereby making possible greater short-run enterprise adjustments to changing product prices.

Beginning farmers should plan, therefore, according to their own managerial abilities, farm conditions and resource supplies, if they wish to maximize profits. No one farm plan is best for all farmers on the same soil type and with the same management ability and resource limitations. Hence, the most profitable organization of enterprises, or allocation of resources, for beginning farmers depends on (1) existing price relationships, (2) availability of capital, labor and livestock housing, (3) managerial ability, and (4) the input-output relationships for the crop and livestock enterprises considered.

ACKNOWLEDGMENTS

The author wishes to express his appreciation to Dr. Earl O. Heady for his supervision, criticisms, suggestions, and stimulating counsel throughout the entire study.

Further acknowledgments are given to Dr. John T. Pesek of the Agronomy Department for providing the basic yield data and advice on crop production, Messrs. Carl Malone, Herbert G. Howell, Charles Donhowe, Richard O. Pulse, and Herbert R. Allen of the Extension Service for advice and criticisms throughout this study; and the Iowa Agricultural Extension Service for making this study possible.

A special note of gratitude is due my wife for encouragement and support during my entire graduate study and for proof reading this manuscript.

APPENDIX

BASIC DATA USED IN COMPUTING PRODUCTION AND RESOURCE REQUIREMENTS OF LIVESTOCK ENTERPRISES

Livestock Enterprises

As described in the chapter on Area of Study and Enterprises Considered, two levels of management or production efficiency, average and above-average, were assumed for all livestock enterprises except feeder cattle. Feeder cattle were considered only at above-average because of the high capital requirements and risks associated with feeding cattle. Hence, feeding cattle was not considered a feasible investment alternative for tenants with average managerial ability.

The estimates of the resource requirements for each of the enterprises considered were obtained from published and unpublished results of studies conducted by the Iowa Agricultural Experiment Station and agricultural experiment stations of surrounding states. The data were drawn largely from records kept on farms rather than from experimental work. In cases where data were not available it became necessary to resort to the use of estimates based upon the judgment of persons familiar with the enterprises. The estimates used in this study are believed to be those most nearly representative of the resource requirements and the production that actually exist in central Iowa.

Dairy enterprises

The basic input-output data for the dairy enterprises (Table 24) were obtained from published reports from Iowa State College, University of Minnesota, University of Illinois and the Iowa Crop and Livestock Reporting Service. Milk production for the dairy enterprise with average management was based on the average annual milk production for Hardin County for the period of 1945-1949 and adjusted to the 1953 milk production as reported by Crop Reporting District II.[1] Milk production for the dairy enterprise with above-average management was adapted from farm records in Illinois and Minnesota.[2]

The feed and capital requirements for the dairy enterprises were based on one cow and replacements which includes the equivalent of one-third of a calf, one-third of a 1-year old, and one-fourth of a 2-year old.[3] The productive life of a cow was assumed to be 4.47 years. Feed requirements for

---

[1]Iowa Crop Reporting Service, Des Moines, Iowa.

[2]University of Illinois, Farm Bureau Farm Management Service, Annual Reports 1949-53, Urbana, Illinois and Rorholm, Niels, et al., Farm labor and farm costs, 1953, Minn. Report No. 217, Dept. Agr. Econ. University Farm, St. Paul, Minnesota, Sept. 1954.

[3]Ingels, John and Cannon, C. Y. The mortality of calves in the Iowa State College Dairy Herd. Reprint of Proceedings of Am. Soc. of Animal Production. 1936.

the dairy enterprise with average management were adapted from data reported for Iowa for the period 1948-1952 by the United States Department of Agriculture[1] and adjusted for the milk production for Hardin County. Feed requirements for the above-average dairy enterprise were adapted from farm records in Illinois and Minnesota. Capital requirements for both average and above-average dairy enterprises were adapted from Iowa Technical Bulletin 390[2] and Minnesota Report No. 217.

The labor inputs per cow are also given in Table 24. The estimates given were derived on the basis of the following studies: Iowa Research Bulletin 390, Iowa Technical Bulletin 278, and the Minnesota Farm Business Records.

Swine enterprises

The two types of swine enterprises considered in this study were spring-farrowed hogs fed on pasture and fall-farrowed hogs fed on drylot. Two levels of management or production efficiency (average and above-average) were considered for each type of hog enterprise. The basic input-output data for the swine enterprises are shown in Table 25.

---

[1]Rations fed to milk cows. United States Department of Agriculture. Washington D.C. U.S. Govt. Print. Off. 1954.

[2]Heady, E. O. and Olsen, R. O. Substitution relationships, resource requirements and income variability in utilization of forage crops. Iowa Agr. Exp. Sta. Res. Bul. 390. 1952.

Table 24. Basic input-output data for the dairy enterprise on a cow basis (including replacements)

Production and resource requirements per head	Level of management	
	Average	Above-average
Pounds of feed		
Corn equivalent	2,504.00	3,698.90
Supplement	175.00	436.00
Hay equivalent	12,956.00	13,672.00
Labor (hrs.)	124.00	129.00
Building (sq. ft.)	84.00	84.00
Production (lbs.)		
Milk	6,000.00	9,429.70
Cull cow	268.46	268.46
2-year old	74.00	74.00
1-year old	5.23	5.23
Veal	39.60	39.60
Capital expense ($)		
Use of equipment	.88	.88
Taxes and insurance on cows	.95	.95
Breeding fees	6.00	6.00
Commercial feed	7.99	19.90
Hauling hay from field	3.60	4.32
Power	4.12	4.77
Miscellaneous	9.04	9.04
Total cash expense	32.58	45.86
Capital investment ($)		
Cows	188.95	250.00
Equipment	14.72	14.72
Total capital (investment and expense) ($)	203.67	264.72

Table 25. Basic input-output data for swine feeding systems on a head basis

Production and resource requirements	Unit	Spring pigs, pasture		Fall pigs, drylot	
		Average management	Above-average management	Average management	Above-average management
Pigs weaned/litter	no.	6.778	7.33	6.68	7.23
Pigs sold/litter	no.	5.439	6.11	6.346	7.01
Total production					
Market hogs	lbs.	1,223.775	1,374.75	1,427.85	1,577.00
Sow	lbs.	300.00	300.00	100.00	100.00
Total	lbs.	1,523.775	1,674.75	1,527.85	1,677.00
Feed per 100 lbs. pork marketed					
Corn equivalent	lbs.	436.89	322.78	480.58	355.06
Protein supplement	lbs.	43.90	46.00	47.30	51.00
Hay equivalent	lbs.	94.30	83.30	0	0
Capital investment per 100 lbs.					
Sow	$	4.47	4.48	4.46	4.48
Equipment	$	1.49	1.89	1.61	1.62
Total	$	5.96	6.37	6.07	6.10
Annual cash expense per 100 lbs.					
Protein supplement	$	1.96	2.58	2.16	2.86
Power	$	.65	.65	.65	.65
Use of equipment	$	.67	.67	.67	.67
Miscellaneous	$	.83	.80	.83	.80
Boar service	$	.13	.09	.13	.09
Total cash expense	$	4.24	4.79	4.44	5.07
Capital coefficient	$	10.65	11.16	10.51	11.17
Labor per litter	hrs.	26.00	26.00	33.00	33.00

The number of pigs weaned per litter with average management represented a five-year average for Iowa for the period 1950-54 as reported by the Iowa Crop and Livestock Reporting Service. The pigs weaned per litter for the above-average hog enterprise were adapted from farm records in Illinois and Minnesota.[1] Total production, for both levels of management, was based on an assumed market weight for hogs of 225 pounds. The feed and capital requirements were based on the pounds of pork marketed which included both market hogs and sow. Feed and capital requirements per 100 pounds of pork were adapted from farm records in Illinois.[2]

The estimates for the labor required per litter were derived essentially from the Purdue University Bulletin 565, 1951.[3]

Feeder cattle enterprises

The three types of feeder cattle enterprises considered

---

[1]University of Illinois Farm Bureau Farm Management Service, 1953-54, Urbana, Illinois, and University of Minnesota Department of Agricultural Economics, Annual reports of farm management service, Report numbers 206, 214, and 215, 1953-54, St. Paul, Minnesota.

[2]Wilcox, R. H. and Hananmeyer, G. D. Detail cost report for Central Illinois, 1952. Dept. Agr. Econ. Univ. Ill. AE2969. 1953.

[3]Hardin, Lowell S., et al. Hogs, one- and two-litter systems compared. Purdue Univ. Agr. Exp. Sta. Bul. 565. Nov. 1951.

in this study are medium yearlings fed in drylot, choice calves fed in drylot, and choice calves fed on pasture. As explained previously, only one level of feeding efficiency or management level, above-average, was considered for feeder cattle because these enterprises were not considered as feasible investment opportunities for tenants with only average managerial ability. The basic input-output data for the three feeder cattle enterprises are given in Table 26.

The feed and capital requirements for feeder cattle were adapted from a summary of farm records in Iowa and Illinois. Feed requirements for the three feeding enterprises were derived primarily from annual reports on feeder cattle in Illinois for the period of 1938-54 and from Iowa Agricultural Extension Service Pamphlet 127, 1950. Capital requirements were adapted from a detail cost report for feeding cattle in central Illinois in 1952, Illinois Agricultural Economics Publication A.E. 2969, November 1953.

The labor requirements per head were adapted from Iowa Technical Bulletin 390. These data were adapted to fit the particular feeding system on the basis of purchase and selling dates. The dates associated with each enterprise were adapted from Iowa Agricultural Experiment Station and Extension Service Bulletin 299, 1949.

Table 26. Basic input-output data for cattle feeding systems on a head basis

	Unit	Choice feeder calves		Medium yearlings
		Drylot	Pasture	Drylot
Purchase date		October	October	November
Marketing date		August	September	April-May
Initial weight	lbs.	430.0	430.0	670.0
Market weight	lbs.	980.0	990.0	957.0
Net gain	lbs.	550.0	560.0	287.0
Days on farm		325.0	345.0	184.0
Gain per day	lbs.	1.7	1.6	1.5
Death loss	percent	2.5	2.5	1.5
Feed fed per head				
Corn equivalent	bus.	61.0	50.0	33.0
Supplement	lbs.	257.0	229.0	134.0
Hay	lbs.	1,409.0	1,766.0	1,338.0
Pasture	acres	0	.7	0
Hay equivalent	lbs.	1,409.0	3,206.0	1,338.0
Labor	hrs.	17.4	18.6	13.6
Annual cash expense				
Protein	$	12.28	10.94	6.40
Power	$	2.31	2.35	1.21
Equipment	$	2.42	2.46	1.26
Miscellaneous cost	$	2.26	2.30	1.18
Death loss	$	2.59	2.59	1.84
Feeder stock	$	103.61	103.61	122.94
Total annual expense	$	125.47	124.25	134.83
Capital investment	$	13.50	13.50	13.50
Total capital outlay	$	138.97	137.76	148.33

Poultry enterprises

The data in Table 27 for the supplementary poultry enterprises considered in this study were obtained from farm flock demonstration records in Iowa and Minnesota. Egg production for average poultry management represented an average for all farms in Hardin County in 1953 as reported by the Iowa Crop and Livestock Reporting Service.[1] Egg production for above-average poultry management represented an average annual egg production for the "high farms" in the Iowa poultry demonstration flocks for the period 1950-54. Estimates of the feed and capital requirements for the two levels of management were derived from data given in Minnesota farm poultry flock returns 1947-52, Minnesota Report No. 212, December 1953. The data for the Minnesota studies were obtained from farmers in southern Minnesota and these data compared very favorably with the Iowa farm flock demonstration studies. Since the Minnesota data were more complete than the Iowa data, and since the data from both sources compared quite favorably, the Minnesota data were used.

---

[1]Iowa Crop and Livestock Reporting Service, Iowa egg production by counties. Des Moines. 1953.

Table 27. Basic input-output data for poultry on a hen basis (including replacements) for two levels of management

Item	Unit	Average	Above-average
Output			
Eggs	doz.	15.00	19.17
Meat	lbs.	4.87	4.87
Inputs			
Grain	lbs.	91.09	93.09
Commercial feed	lbs.	41.99	45.99
Labor	hrs.	2.10	2.10
Cash expense			
Sexed chicks (each)	$	.35	.35
Commercial feed	$	2.07	2.26
Power	$	.06	.06
Equipment	$	.22	.22
Miscellaneous	$	.15	.15
Total cash expenses	$	2.84	3.04
Investment in equipment	$	1.15	1.15
Total capital outlay	$	3.99	4.19
Building	sq. ft.	4.12	4.12
Hen mortality	percent	15.00	15.00
Chick mortality	percent	10.00	10.00